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PROVO UT COMPUTER AIDED MFG LAB D K ALLEN ET AL.
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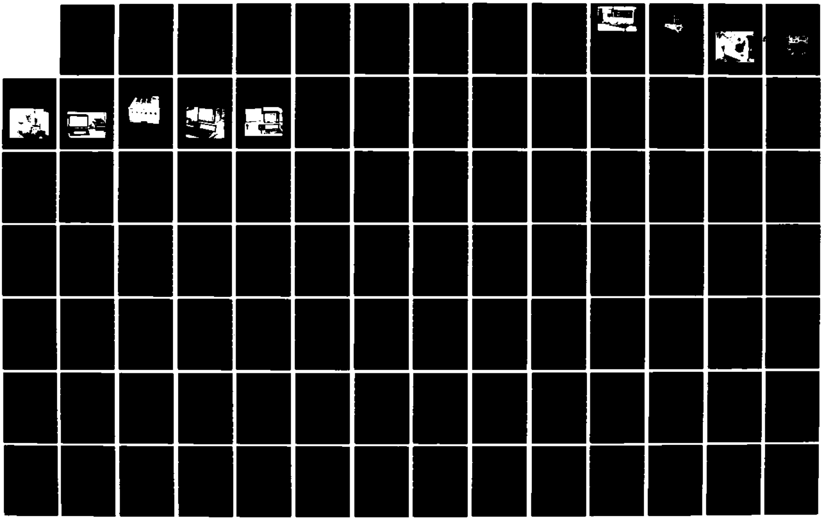

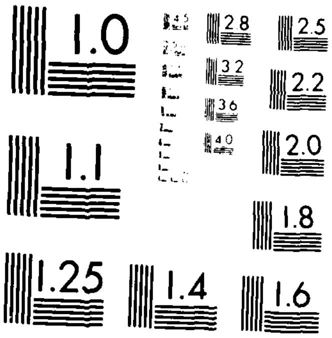

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FINAL REPORT

AFOSR Grant #82-0253
July 1, 1982 through October 31, 1984

MANUFACTURING INFORMATION SYSTEM

Submitted to

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Building 410, Room 223
Bolling Air Force Base
Washington, D.C. 20322 N.C.

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Principal Investigators:
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This is the final report of a project to develop prototype miniature laboratory apparatus to be used in conducting a series of experiments and investigations relating to a Manufacturing Information System.

The size and cost of manufacturing equipment has made it extremely difficult to perform realistic modeling and simulation of the manufacturing process in university research laboratories. Likewise the size and cost factors, coupled with many uncontrolled variables of the production situation has even made it difficult to perform adequate manufacturing research in the industrial setting.

The difficulty of developing Integrated Manufacturing Systems is well documented by the large amount of funding and effort being spent by industry and government. One example

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of a large scale industry/government program was the I-CAM project. This project lasting 10 years and $250M has been only partially successful, attesting to the difficulty of the integration challenge.

It was the purpose for research funded under this grant to continue the development of miniature prototype equipment for use in an integrated CAD/CAM Laboratory. The equipment developed under this grant and from previous work is capable of actually performing production operations (e.g. drilling, milling, turning, punching, etc.) on metallic and non-metallic workpieces.

It is now expected that the prototype equipment developed or otherwise acquired under this grant will now provide the basis for extensive research on Manufacturing Information Systems, Common Database Development, CIM Application Program Development, Local Area Networking, and Knowledge-based CAD/CAM Training utilizing Interactive Videodisc Delivery Systems.

A-1

MANUFACTURING INFORMATION SYSTEM

(Equipment Development Phase)

1. INTRODUCTION

This is the final technical report for research completed during a 28-month effort to develop prototype aboratory sized manufacturing equipment for use in Manufacturing Information System research.

1.1 NEED

In response to a long-felt need and effort to improve manufacturing engineering/technology education, the development of a full sized computer aided manufacturing (CAM) laboratory was undertaken at Brigham Young University in 1974 as a BYU Centennial year activity. The purpose of this laboratory was to provide advanced facilities for 1) teaching, 2) research, and 3) technology transfer. By 1976 a building had been erected for the laboratory and a number of pieces of full sized industrial CAD/CAM equipment had been acquired through cost-sharing and educational contributions. One hope for the CAM Laboratory was to develop a fully integrated system for linking the Applicon Computer Graphics System to a host computer PDP 11/40 Industrial Control Computer for process planning, scheduling, and N/C programming. The control information was then to be down-loaded to individual machines for producing the various parts. Machines acquired for the full-sized CAM Lab inculded a K & T MM100 CNC milling machine, a Sheldon Model 1710 tape lathe with an Allen-Bradley 7360 CNC conrol unit, An Eaton- Kenway Automated Storage and Retrieval System (AS/RS) for parts storage, and an ASEA Industrial Robot Model Rb-6 for processing, inspection and assembly.

1.2 PROBLEM

As the work of integration started at BYU, it was soon discovered that two classes of problems existed. First it became apparent that many smaller problems had to be solved in physically linking and logically inter-connecting the various full-sized pieces of equipment. For example, it was discovered that the Bendix Cordax inspection machine could not use the graphics data base for inspecting parts produced on the CNC Milling Machine. The graphics data base did not have tolerances stored for the various dimensions. Also, the graphics data base for the wire frame model did not store relationships between the various form features.

It was soon discovered that the BYU integration problems were not unique. The major Government/Industry Integration effort of I-CAM ran into problems as well. The initial work of the I-CAM project had as its central focus "Database and Database Automation". This central focus was changed after several months to that of developing "generic architecture" models. It is the condsidered opinion of at least one of the principal investigators of this project that there is not a "generic architecture" which will fit all of the manufacturing companies except at the highest levels of abstraction. The detailed architectural diagrams produced by various contractors have not provided the basis for integration. It was the intent of the Manufacturing Information System research to focus on database and database automation which had been earlier abandoned.

The second class of problems dealt with teaching. There was a pressing challenge of how to teach the various graduate and undergraduate classes dealing with advanced manufacturing technology and systems integration.

The full-sized production equipment of the CAM Lab requires a considerable amount of floor space, is expensive to operate and maintain, and because of this it was not feasible to provide multiple work stations. Furthermore, the equipment is a little dangerous to operate with large numbers of student operators and it requires quite a large amount of materials. In order to solve the materials problem styrofoam blocks were used for workpieces. Styrofoam was a good choice since it readily yields in case a student has incorrectly programmed the 20 h.p. milling machine and it suddenly starts moving at rapid traverse rate while the tool is still in the cut. However machining of styrofoam does not present a very realistic exposure to manufacturing problems. Realistic problems such as tool wear, cutting fluid secretion and application, etc. cannot be studied very efficiently when machining styrofoam.

1.3 Proposed Solution

It was postulated that the solution to integration of manufacturing systems is based on the development of a common data base, distributed computing, and local area networking, or in other words, the availability an use of an appropriate manufacturing information system. In order to evaluate this postulate, plans were made to construct a miniature factory and to install a series of microcomputers, databases, and a local area networking system for use in information systems research and teaching. AFOSR Grant No. 82-0253 has greatly assisted in accelerating the development of prototype laboratory equipment for this continuing work.

1.4 Historical Background

The concept of developing a miniature factory had been kicked around since 1976 when one of the principal investigators had visited Caterpillar Tractor Company and had seen some miniature materials handling equipment. The concept of developing a duplicate of the regular full-sized CAM Lab on a miniature scale was first described in a memorandum dated 22 May 1979 from D.K. Allen to J.J. Kunzler. In this memorandum it was mentioned that a Tektronix 4051 Graphics Display System had been donated as had funds to purchase a mini-lathe. Matching college and department funds were requested to purchase a Macsym II Process Control Computer so that interfacing it with the mini-lathe could begin.

Initially the Tektronix 4051 Graphics System had been used to introduce students to concepts of parametric design. With this approach, a part family, based on Group Technology concepts, could be displayed, dimensions added, and the drawing automatically scaled to size. The miniature lathe which was to be interfaced to the Macsym controller, which was to in turn be interfaced to the Tektronix 4051, was actually designed as a camera maker's lathe but had been retrofitted with ball-screws and digital stepper motors to permit its use for numerical control applications. In April, 1979, Superior Electric Company provided a very generous discount for stepping motor controllers to be used in conjunction with the Mini-Lab project.

With initial concepts and all of the equipment in place, Mr. Charles Snead, a graduate student enrolled in the M.S. Degree Program of Computer Aided Manufacturing was asked to begin the integration process by linking the Tektronix Graphics System, Macsym Process Control Computer and miniature lathe. The result was most encouraging. He was able to incorporate parametric design with N/C Cutterpath generation to produce a family of rotational parts having 1, 2, or 3 diameters.

One problem with the Macsym-based system was the very slow positioning rates for the lathe because all of the processing was being performed in BASIC. With this approach it would take nearly twenty minutes to machine a simple part. Subsequently, Mr. Steve Painter of Grady Moore Associates was asked to develop a higher speed stepper motor driver that could be used with the popular and low-cost Apple II Microcomputer instead of using the more expensive and slower approach using the Macsym II Computer. This development of the new controller took nearly 18 months, with one false start, but eventually ended up with a very fast 6-axis controller which could be controlled by the Apple II computer.

In order to expand the integration concept to include other equipment, the BYU Industrial Design Department was contacted in the late spring of 1981 and asked to produce mock-up equipment for use in the Mini-Lab. Professor Allen provided specifications and met with the students many times during the development phase to review and approve their work. On June 22, 1981, an open house was held in which students discussed their projects with members of the local industrial community.

In the fall of 1981, Mr. Forest Blair, a student in mechanical engineering was employed to produce assembly and retail drawings for the new miniature machine tools. Mr. Paul Smith worked closely with the project and with other graduate students who were developing and testing this miniature equipment as part of their thesis work. This work included designing the miniature turret punch, automated storage and retrieval system, and industrial robot. Because of difficulties in designing a milling machine in accordance with the plastic mock-up provided by the industrial design department, Professor Allen developed in May of 1982 an innovative design for a polar-coordinate milling machine. A patent has since been applied for on this design.

It was about this time that the CAM Laboratory was visited by Mr. Thomas Walsh, AFOSR for the purpose of exploring possible mutually beneficial research interests. As a follow up of his visit, an unsolicited proposal was submitted to AFOSR on November 6, 1981 to fund a 24 month grant for continued development of the Mini-Lab and to then use the apparatus so developed in research directed toward development of an integrated Manufacturing Information System. Although funding for the project did not begin until July of 1982, work was going on using internal funding.

The projected Manufacturing Information System research was described as including three phases. Phase I included the development of suitable laboratory apparatus, Phase II included development of software exchange specifications, standards, integration software, and necessary architecture models, and Phase III included subdividing the responsibility for creating applications programs among a number of research institutions.

Some slippage occurred in meeting this planned schedule because the principal investigators did not realize that the project would be funded on an annual basis beginning in July 1982 rather than on a 24-month basis as planned. Subsequently, a continuation proposal was prepared and submitted July 14, 1983. a no-cost extension was approved as was funding for the completion of Phase I of the project.

The following sections describe the mission and goals of the project, work performed to date, deliverables, and a summary and conclusions section.

2. MISSION AND GOALS

The mission of the project was to develop and test scaled-down manufacturing equipment and systems as a basis for manufacturing information system research, manufacturing simulation studies, and manufacturing education related to system integration. Eight goals for accomplishing the stated mission were identified. Only the tree goals for Phase I are show here. Goals for Phases II and III are contained in the original proposal.

Goal 1. Design and develop laboratory-size prototype production equipment for processing and handling of box-like, sheet, and rotational parts made from metallic and non-metallic materials.

Goal 2. Design and develop a small, microprocessor-based, computer numerical control (CNC) system for controlling both processing and handling equipment.

Goal 3. Develop and test the CAD/CAM interface between a small computer graphics display device and the CNC processing and handling system.

For each of the identified goals a series of smaller tasks were identified along with a time schedule for completion of each task.

3. PROJECT OVERVIEW AND DELIVERIES

In accordance with the mission and goals statement given above this section is devoted to a description of the hardware and software designs resulting from this project. The prototype hardware designs are divided into two broad categories: The first category deals with the design and development of laboratory-sized production equipment for fabricating metallic and non-metallic piece parts, and the second category deals with equipment control system hardware, interfaces, and electronic switching.

Software designs have also been divided into two categories: The first category deals with communication and control software required to communicate between the host computer and the equipment controllers themselves, and the second category deals with application software to demonstrate the feasibility of using parametric design concepts, and automatic cutterpath generation techniques in a "paperless factory" environment. The use of parametric techniques for defining individual pieceparts has been quite extensively used at BYU and is now being quite widely espoused. Some of the underlying work for parametric design is based on the Part Family Classification which contains some 240 basic shapes composed of primative shapes and some 80 form features. With this system is is possible to generat literally millions of combinations of geometric configurations which can then be used in generative design, family of part programming, tool design, estimating, etc.

The overall architecture for the integrated manufacturing system is shown in Fig. 1. In this system, IBM PC's are used for design and scheduling, while Apple II microcomputers are used for machine controllers in conjunction with stepper motor drivers to actually position each of the machines.

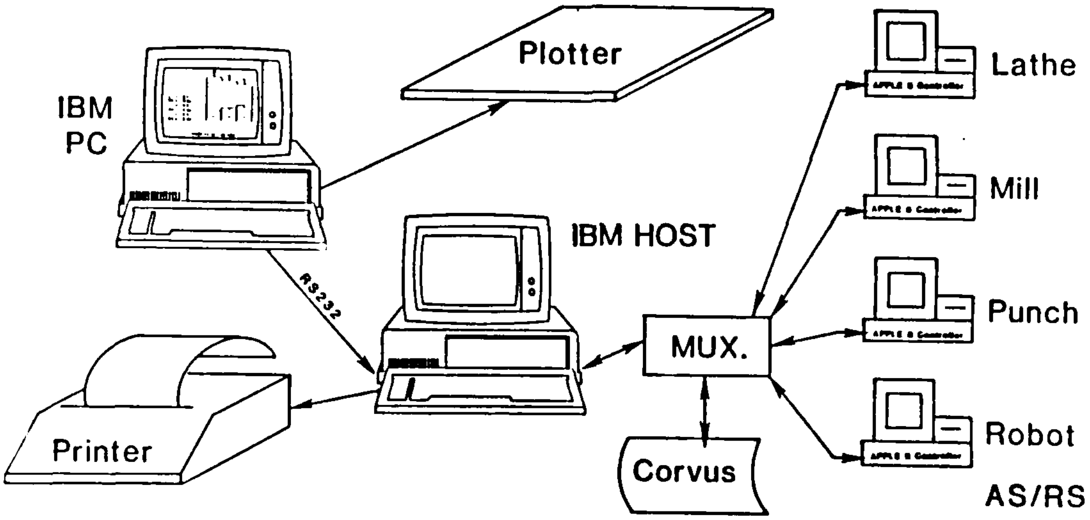


Fig. 1 - Architecture for Integrated Manufacturing Information System

3.1 Design of Laboratory Sized Production Equipment

Designs for each of the following prototype equipments are described below along with specifications, photographs and description. Detailed working drawings for machines produced under this grant and from other funding sources are provided in the appendices.

3.1.1 Automated Storage and Retrieval System (AS/RS)

Automated materials handling is one of the major components of an integrated factory. Information flow often parallels and preceeds material flow, thus design of the material handling system provides a basis for also designing the Manufacturing Information System.

General design specifications for the AS/RS are as follows:

a) Bin capacity	2 lbs
b) Bin size	3" x 4" x 8" long
c) No. bins	18
d) Traverse rate	100"/min

The AS/RS, shown in Fig. 2, is approximately 55" long and 23" high. It is equipped with ball screws and three slo-syn digital stepper-motor drives for positioning and bin retraction.

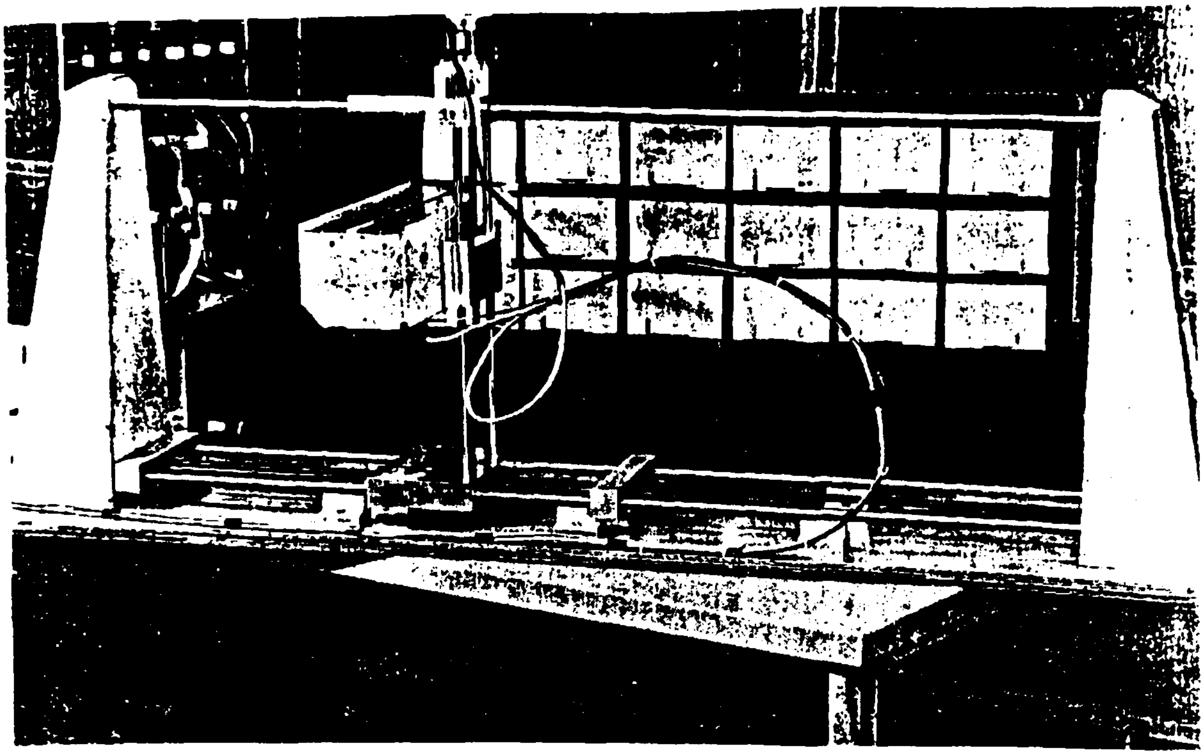


Fig. 2 - Miniature Automated Storage/Retrieval System

The AS/RS unit has 18 bins which can be used for storage of raw materials, in-process inventory, finished goods, or tooling. Box-like materials are staggered in height to facilitate removal. Rod-like materials are supported on an inclined plane so they roll into position to be gripped by the robot. Sheet stock is stored flat, and requires the development of a vacuum gripper mechanism to aid in its removal. Detailed design drawings for the miniature AS/RS are contained in Appendix A.

3.1.2 Miniature Sheet-metal Turret Punch

One of the important "wedges" in the I-CAM project was the development of a sheet-metal cell. Since there are a variety of expert opinions as to what should constitute such a cell, the intent of our project was to develop one standard miniature piece of equipment which would appear in most full-sized cells and which would provide the basis for information flow to a sheet metal center as well as provide a system which could be used for modeling and simulation of the sheet metal production process.

General design specifications for the turret punch are as follows:

a) Sheet stock size	4" x 8"
b) Material paper card stock	.020" thick
c) Turret capacity	8 tools
d) Punching capacity	1/4" dia.
e) Positioning rate	0-50"/min.

The turret punch, shown in Fig. 3, can be used to produce holes, cut-outs, and re-entrants of various sizes depending upon which tools are in the turret. Some additional work must still be done to increase punching capacity and punch alignment.

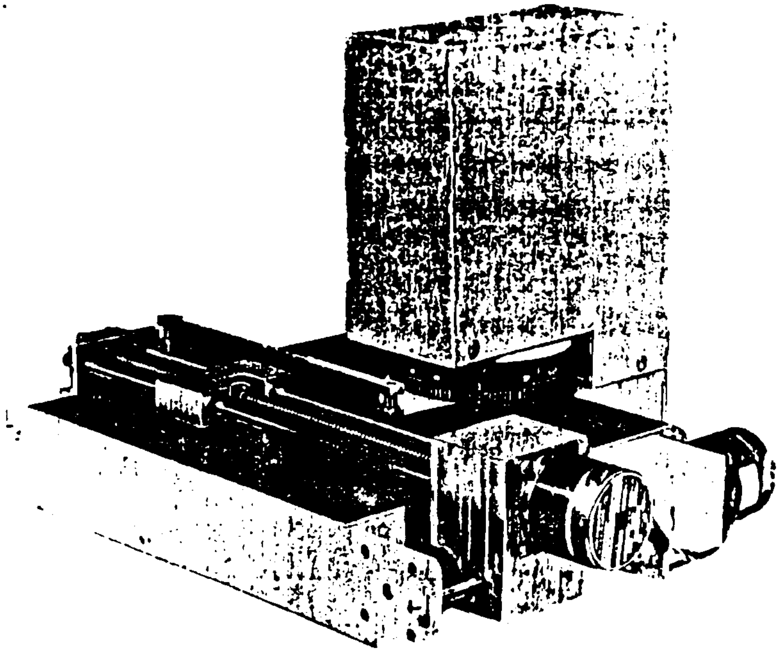


Fig. 3 - Miniature Sheet-metal Turret Punch

Detailed designs for the miniature turret punch are contained in Appendix B.

3.1.3 Milling Machine

Prior to the start of the AFOSR grant, a small horizontal spindle drilling machine had been acquired and outfitted with ball-screws and stepper motors to perform the functions of a milling machine. However, the spindle was too heavy to be elevated by the stepper-motor drives. Consequently, plans were made to design another horizontal mill and to make as many components as possible interchangeable with the new lathe to be designed. In the spring of 1981, the CAM Lab had also been approached by Digital Equipment Co. Industrial Design Department to develop a small milling machine to be connected to a graphic workstation for producing 3-dimensional sculptured surfaces. Rather than design a second horizontal spindle milling machine specifically for the Manufacturing Information System project, it was decided to use the design which had been made to satisfy the needs of Digital Equipment Company. This design, called the polar-coordinate mill, while especially suited for producing sculptured and contoured surfaces, seemed to be viable for use with the project at hand. Since the design was already available for the polar coordinate mill this approach provided a way to save some valuable development time.

The original design specifications for a horizontal milling machine have been met with the polar-coordinate milling machine with the exception of the spindle thread and the four position indexable turret. The available spindle had only a 1/4" dia. straight shaft. The indexable turret now has 360^{0} of rotation instead of just four positions called for in the original specifications.

The design specifications for the milling machine are as follows:

a)	Size capacity	4" cube
b)	Drill motor	1/10 HP
c)	Spindle speeds	0-2000 rpm
d)	Positioning rate	0-50 in/min
e)	Resolution	0.005 in/step
f)	Materials,	styrofoam, machinable wax, etc.

The polar-coordinate milling machine is shown in Figure 4. The machine utilizes a over-arm design in which adjustable track rollers ride in a hardened and ground V-groove. The overarm can sweep 180 degrees across the top of the object to be machined and at the same time the workpiece, mounted on the rotary table can be simultaneously rotated and traversed past the cutter. With this design it is now possible to machine five sides of a workpiece without refixturing it for each surface.

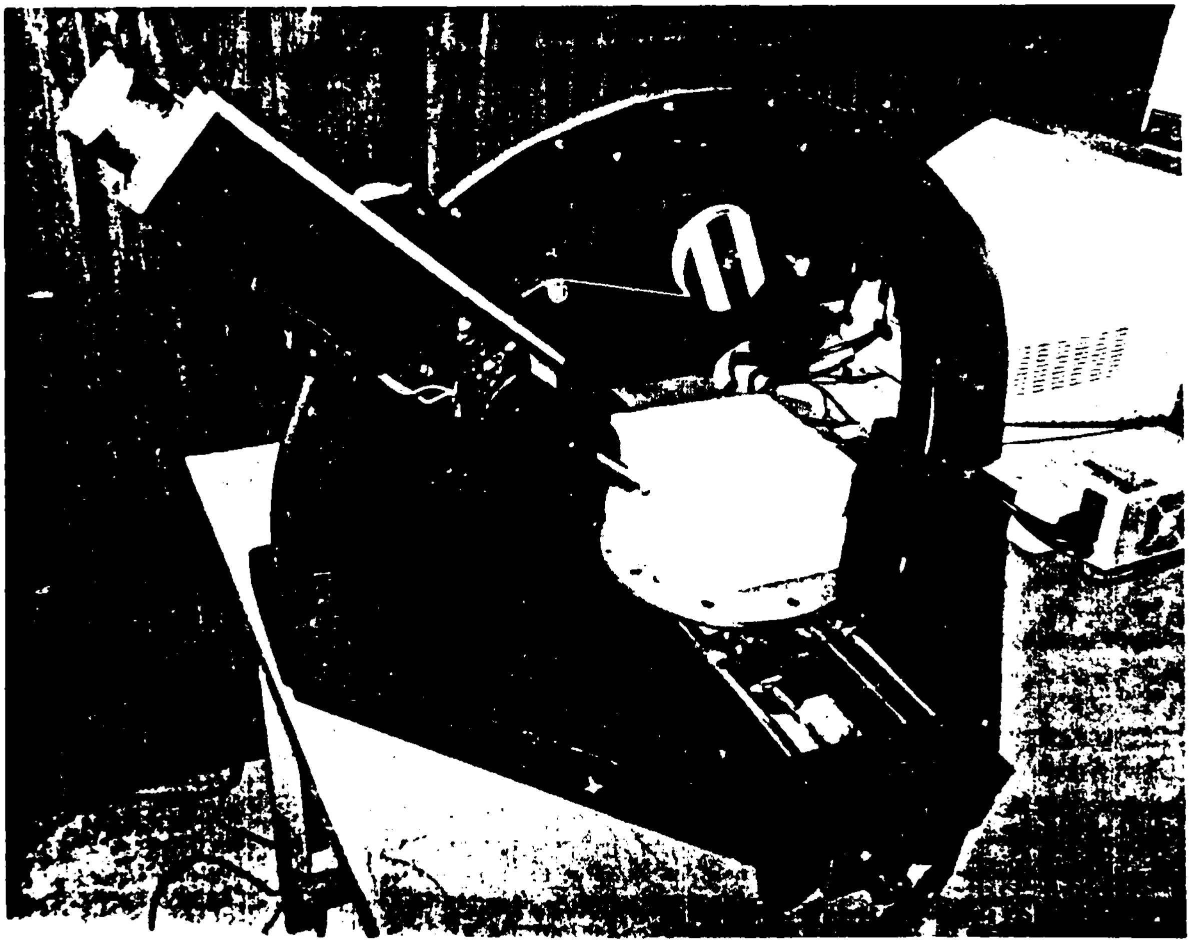


Fig. 4 - Polar-coordinate Milling Machine

Detailed designs for the polar-coordinate milling machine are contained in Appendix C.

3.1.4 CNC Turret Lathe

The original specifications for a computer controlled lathe called for: (a) 2" swing, (b) 6" between centers, (c) 1/10 H.P. spindle motor, 0-200 rpm, (d) positioning rate of 0-50"/minute, (e) positioning resolution 0.0005"/step, and a spindle with 5/8-11 UNC threads. The machine was to be equipped with 1/4" square shank tools, to be mounted in a four-station turret for machining aluminum, brass, plastic, wood and other soft materials.

At the beginning of the project, miniature working equipment was essentially unavailable for laboratory use and thus had to be designed and constructed from the ground up. The detailed designs for the miniature lathe are contained in Appendix D. However, a few miniature lathes have now appeared on the market which satisfy or exceed the original design specifications. By combining resources from several funding sources it was possible to purchase a commercially available miniature lathe and associated tooling rather than go through the development process. A photograph of the commercially available CNC turret lathe acquired for this project is shown in Figure 5.

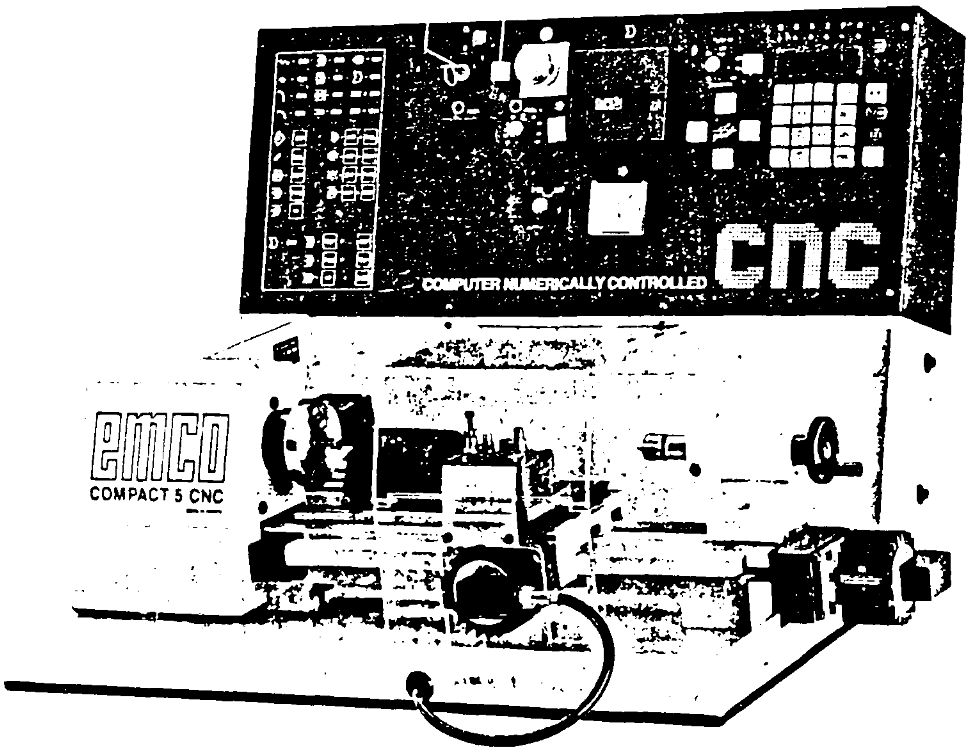
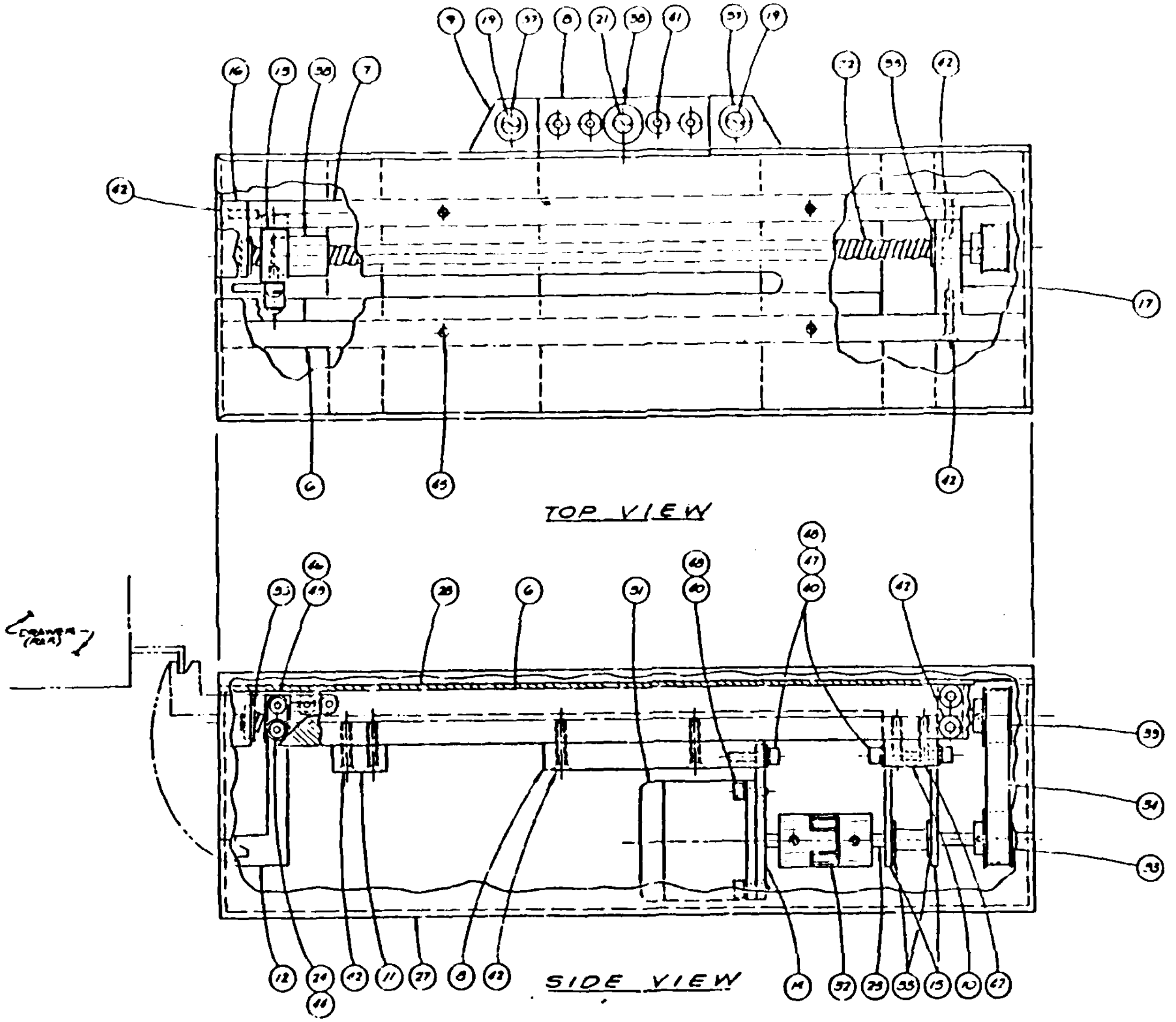


Fig. 5 - CNC Turret Lathe

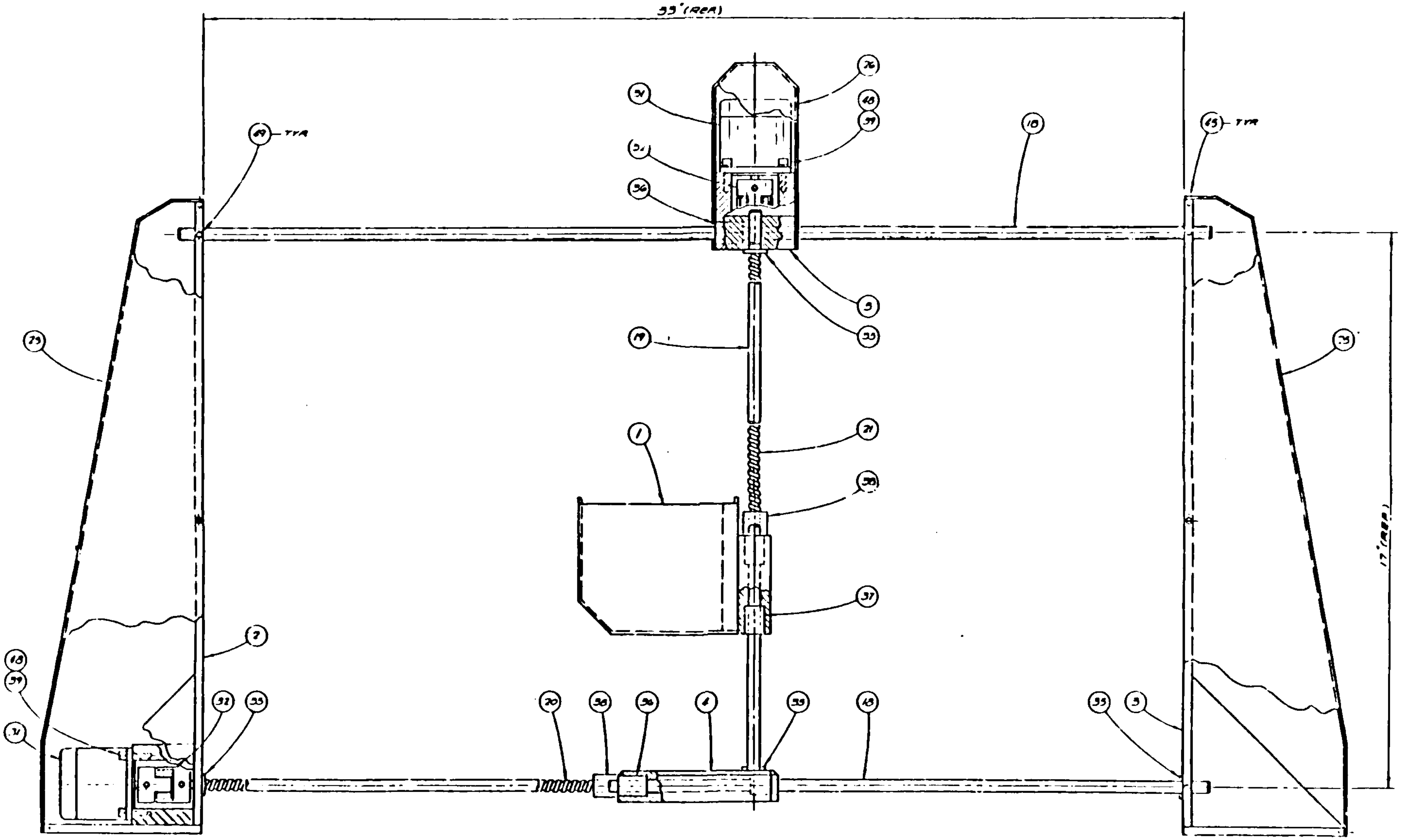
The lathe does not quite have the resolution desired but it does more than compensate in other ways. For example the main drive motor is four times as powerful and it also was a six-station indexable turret instead of the four



NOTES
1 ALL ITEMS MARKED THUS ○ ARE FOUND ON BILL OF MATERIALS Nº M0010.

DETAIL ITEM (1)
SCALE: FULL

SEPTEMBER 23, 1981 CAD-CAM DEPT.	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	MINI - STACKER	SUB-ASSEMBLY - DETAIL ITEM 1		FORREST CLAIR	CC11



FRONT ELEVATION

SCALE: 3/16"=1'

NOTES

1. ALL ITEMS MARKED THUS ○ ARE FOUND ON BILL OF MATERIALS NO. MC010.

BRIGHAM YOUNG UNIVERSITY	MINI - STACKER	ASSEMBLY - ELEVATION	FORREST CLAIR

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY		Project No.	Drawing No 00010	Sheet 6 of
Prepared by FORREST BLAIR	Date 10-15-81	REVISIONS		
Approved by	Date	NO.	DESCRIPTION	DATE
Project Engineer	Date			
Project Name CAD-CAM				
Drawing Title MINI-STACKER				

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
43	0011	Machine Screw - Slotted	1	C. Steel	
		Binding Head, #8-32 UNC x 3/8" Lg.			
44	0010	Machine Screw - Slotted Binding	1	C. Steel	
		Head, #8-32 UNC x 1/2" Long			
45	0010 & 11	Machine Screw - Slotted Flat	4 18	C. Steel	
		Head, #5-40 UNC x 1/4" Long			
46	0011	Washer – Flat, #8	1	C. Steel	
47	0011	Washer - Flat, #10	6	C. Steel	
48	0010 & 11	Washer - Lock, #10	18	C. Steel	
49	0010	Setscrew, #10	10	C. Steel	
50	0010	Bearing-ABEC 3, Single Shield,	1	Mfg. Std. Stock Drive Prod.	
		5/8" o.d., ¼" Bore, Part No.			
		7Y55-1S6225			
51	0010	Bearing-Thrust, ¼" Bore,	1	Mfg. Std. Stock Drive Prod.	
		Part No. 217-025			

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BRIGHAM YOUNG UNIVERSITY	Project No	Drawing No M0010	Sheet 4 of
Prepared by FORREST BLAIR	Date 10-15-81		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title MINI-STACKER			

REVISIONS NO	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
30		Not Used			
31	0010 & 11	Motor-Stepping, Type SS25	3	Mfg. Std. Slo-Syn	
32	0010 & 11	Coupling-1/4" Nom. Bore,	3	Mfg. Std. Love Joy	
		Model No. LC50			
33	0011	Pulley-Timing Belt, 1/5" Pitch,	2	Mfg. Std. Stock Drive Prod.	
		Flanged for 3/8" Belt, .764 P.D.,			
		1/4" Bore, Cat. No. 6A3-12DF03708			
34	0011	Belt-Timing, 1/5" Pitch,	1	Mfg. Std. Stock Drive Prod.	
		3/3" Width, 35 Grooves, 7.000"			
		Pitch Length, Cat. No. 6G3-35-037			
35	0010 & 11	Bearing-ABEC 3, Flanged,	2	Mfg. Std. Stock Drive Prod.	
		Single Shield, 5/8" O.D., 1/4"			
		Bore, Part No. 7Y55-FS6225			

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BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No M0010	Sheet 5 of
Prepared by FORREST BLAIR	Date 10-15-81		
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Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title MINI-STACKER			

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37	0010 & 11	Bearing-Linear, 5/8" O.D. x 7/8"	4	Mfg. Std. Thompson	
		Long, 3/8" Bore, Cat. No. A-61014			
38	0010 & 11	Ball Nut-For 3/8" Nom. Screw,	3	Mfg. Std. Raceaway	
		Cat. No. RN-0375-0125			
39	0010	Cap Screw - Hex Socket,	8	C. Steel	
		#10-24 UNC x 1" Long			
40	0011	Cap Screw - Hex Socket,	10	C. Steel	
		#10-24 UNC x 3/8" Long			
41	0011	Cap Screw - Flathead Hex Socket,	4	C. Steel	
		#10-24 UNC x 1" Long.			
42	0011	Cap Screw - Flathead Hex Socket,	19	C. Steel	
		#10-24 UNC x 3/4" Long			

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Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title MINI-STACKER			

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
10	0014	Rear Rail Block	1	Aluminum	
11	0014	Front Rail Block	1	Aluminum	
12	0014	Retrieval Hook	1	Aluminum	
13	0014	Hook Attachment Block	1	Aluminum	
14	0015	Motor Support Plate	1	Aluminum	
15	0015	Drive Shaft Support Plate	2	Aluminum	
16	0015	Front Screw Brg. Mount	1	Aluminum	
17	0015	Rear Screw Brg. Mount	1	Aluminum	
18	0016	Horizontal Support Rod	3	C. Steel	
19	0016	Vertical Support Rod	2	C. Steel	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No M0010	Sheet 3 of
Prepared by FORREST BLAIR	Date 10-15-81	REVISIONS	
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title MINI-STACKER			

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
20	0016	Horizontal Drive Screw	1	C. Steel	
21	0016	Vertical Drive Screw	1	C. Steel	
22	0016	Retrieval Mechanism Drive Screw	1	C. Steel	
23	0016	~~Retrieval Mechanism Drive Shaft~~	1	C. Steel	
24	0016	Roller	1	C. Steel	
25	0017	Horizontal Support Cover	2	Acrylic or Equal	
26	0017	Vertical Drive Mount Cover	1	Acrylic or Equal	
27	0018	Retrieval Mechanism Bottom Cover	1	Acrylic or Equal	
28	0018	Retrieval Mechanism Top Cover	1	Acrylic or Equal	
29		Not Used		-	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT

BRIGHAM YOUNG UNIVERSITY

CAD-CAM DEPT.

BILL OF MATERIALS

PROJECT MINI-STACKER (M0010)

DRAWING NO.	DESCRIPTION
0010	ASSEMBLY-ELEVATION
0011	SUB-ASSEMBLY - DETAIL ITEM 1
0012	DETAIL ITEM 2,3,4, & 5
0013	DETAIL ITEM 6 & 7
0014	DETAIL ITEM 8,9,10,11,12 & 13
0015	DETAIL ITEM 14,15,16 & 17
0016	DETAIL ITEM 18,19,20,21,22,23 & 24
0017	DETAIL ITEM 25 & 26
0018	DETAIL ITEM 27 & 28

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY		Project No	Drawing No M0010	Sheet 1 of
Prepared by FORREST BLAIR	Date 10-15-81			
Approved by	Date			
Project Engineer	Date			
Project Name CAD-CAM				
Drawing Title MINI-STACKER				

REVISIONS		
NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED			MATERIAL	DATE
	0010	Mini-Stacker Assembly	1	*			
1	0011	Retrieval Mechanism Assembly		1			
2	0012	Horizontal Support and Motor Mount		1		C. Steel	
3	0012	Horizontal Support Frame		1		C. Steel	
4	0012	Vertical Support Plate		1		Aluminum	
5	0012	Vertical Drive Mount		1		Aluminum	
6	0013	Roller Guide Rail		1		Aluminum	
7	0013	Screw Guide Rail		1		Aluminum	
8	0014	Main Support Plate		1		Aluminum	
9	0014	Vertical Brg. Block		1		Aluminum	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT

APPENDIX A

Detailed Design for Miniature Automated Storage and Retrieval System

3.3.3 CAD/CAM Demonstration Software

A demonstration program was created using the DCLASS System to provide a menu to design a particular part to be produced on the lathe and then transferring this information by means of a parametric program to the NC cutter path generation routine. Following this transfer of data a series of machine motion commands were executed to produce a miniature part as described by the geometry on the CAD system. This demonstration was also extended to generate cutter path moves on the milling machine as well as to exercise the storage and retrieval system to retrieve various materials from the bins.

The demonstration software was used to varify the fact that the machines performed as desired and that the machine controllers were adequate. Documantation and program listings for this software is contained in Appendix M. Some of this work represents the first phases of the integration which is to be conducted under subsequent research activities.

4.0 SUMMARY, And CONCLUSIONS

This development project was successful in designing, constructing, and testing miniature prototype laboratory equipment for use in undertaking a series of investigations relative to informations systems for manufacturing. It is believed, based on the results of this development project, that miniature machine tools can be used to provide a viable alternative to full-sized equipment for use in research and teaching. The miniature equipment with its IBM personal computers and Apple II microcomputers when linked with the CORVUS local area networking system provided the basis for some very preliminary work in developing a fully integrated Manufacturing Information System.

The funding provided was only sufficient to develop prototype equipment, and additional work now needs to be undertaken to enhance this equipment and to use it for more fully investigating requirements of a Manufacturing Information System. It is believed that these requirements include common database development, further exploration of Local Area Networking, and additional work on defining paramentric designs, as well as developing scheduling and control algorithms for the miniature factory.

While there has only been a limited amount of contract AFOSR and Brigham Young University the principal investigators and research staff have tried diligently to live up to the original grant proposal.

Additional funding is now being sought from other agencies and industrial sponsors to continue with the development of this miniature factory to fully exploit the possibilities of developing transportable Manufacturing Information Systems which can be implemented in full-sized factories.

The principal investigators and research staff wish to extend their appreciation to AFOSR for support of this grant.

The Engineering Design Terminal consists of an IBM PC-XT with 10-mb hard disc, 256K memory, parallel and serial parts for communication to other computers in the system and to the combination printer/plotter.

3.3 Communications and Control Software

A variety of software had to be written for use with the Apple II process control computers, the digital stepping motor drivers, hand shaking with the host computer, and demonstration CAD/CAM software to test system communication capabilities.

3.3.1 Machine Controller Software

Each of the miniature machines has several axis of motion ranging from two axis on the lathe to four axis on the polar-coordinate milling machine. Each of these axis is positioned by means of slo-syn digital stepping motors. As many as six of these motors can be controlled from one stepping motor controller interface box. Since each machine is controlled by the Apple II process control computer it is necessary for this computer to send command to each machine via the CY512 controller chip. In each Apple II microcomputer process controller is a Z80 microprocessor. This Z80 microprocessor has been programmed by Prof Smart to use assembly language to pass data from the Apple II process control system to the step motor controller chips located in the step motor controller box. Schematics and assembly code listings for the machine controller software is contained in Appendix G.

3.3.2 Communication Software

A variety of communication packages were created to provide menus for the machine control programs and then transferring these files from the Apple II process control computer to the machine control unit. Both manual and automatic control features were developed. The sequence of program control includes creating a text file containing the NC machine code file with traditional NC commands using N, X, Y, Z, and F functions to represent line number, X coordinate, Y coordinate, Z coordinate and feed rate respectively. The next piece of software was made to interpret and run this command file using the CP/M operating system. The machine language interface and communication program listing is contained in Appendix H. In Appendix I are contained the operating instructions for running the miniature lathe and the miniature milling machine. Appendix J contains a series of CNC programs for the miniature lathe and milling machine. A program written in Applesoft Basic for manually controlling the Turret Punch is contanined in Appendix K. A variety of programs used to control the Storage and Retrieval system with the IBM PC via the Apple conputer are contained in Appendix M. The first program called STACKER.BAS runs on the IBM PC and communicates with the Apple through the serial interface. The second program is also called STACKER.BAS but this one runs on the Apple computer and accepts commands from the IBM PC to produce the desired moves in the miniature AS/RS system.

The computer has a 10-MB Winchester Disk, and 256K memory. It is used to generate process plans based on pre-stored decision tree logic. This terminal is connected to the engineering design terminal via a multiport controller (right) from which it receives part family codes and part parameter values. As mentioned above, these codes and values are then used down-stream by the process control computer to generate machine motion commands.

3.2.4 Engineering Design Terminal

The engineering design terminal shown in Fig. 10 provides both a monochrome menu display and a color graphics display. A three-dimensional graphics software package and tablet/arm have been ordered using university funds for use with this equipment. Composite parametric designs based on group technology principles have been implemented with this system using a ·ew version of the popular BYU Part Family Classification System.

It is expected in a subsequent design of the overall system that other intelligent terminals will be added to perform functions of bill of material processing, master scheduling, market forecasting, and management spread-sheet analysis.

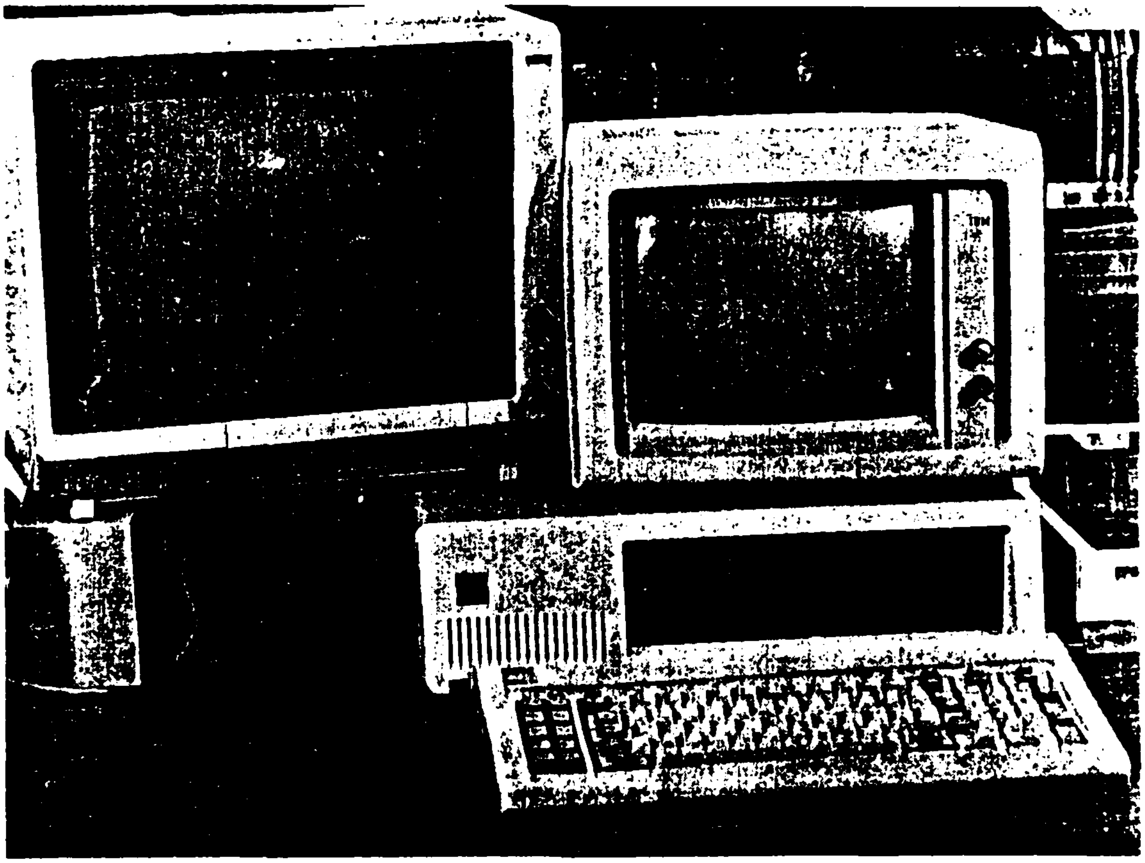


Fig. 10 - Engineering Design Terminal with Monochrome and Color Graphics Display

3.2.2 Computer Controlled Power Switch

A special switch was designed and constructed by Prof Smart to permit the stepper motor control to activate an AC motor upon request by utilizing an opticallyy coupled trial circuit. For example, when a spindle motor is to be turned on, the control program sends a command to the CY512, Stepper Motor Controller device. The CY512 accepts the command and sets a logic bit at one of its output pins. This bit activates the optically coupled triac power switch and the motor turns on. Each computer controlled power switch is capable of controlling three 115 volt AC circuits of up to 12 amps each. Documentation and schematics for the power switch is contained in Appendix F.

.3.2.3 Host Computer System

In the present configuration the host computer shown in the schematic of Fig. 1 would actually be serving a dual function. It would be used for process planning and scheduling as well as performing the functions of the host computer. The host computer functions involve assembling data required for production, hand-shaking with the process control computers, and down-loading parametric data to be used in machine control and cutter-path generation. A photograph of the IBM PC-XT host computer used the the miniature laboratory as part of the manufacturing information system is shown in Fig. 9.

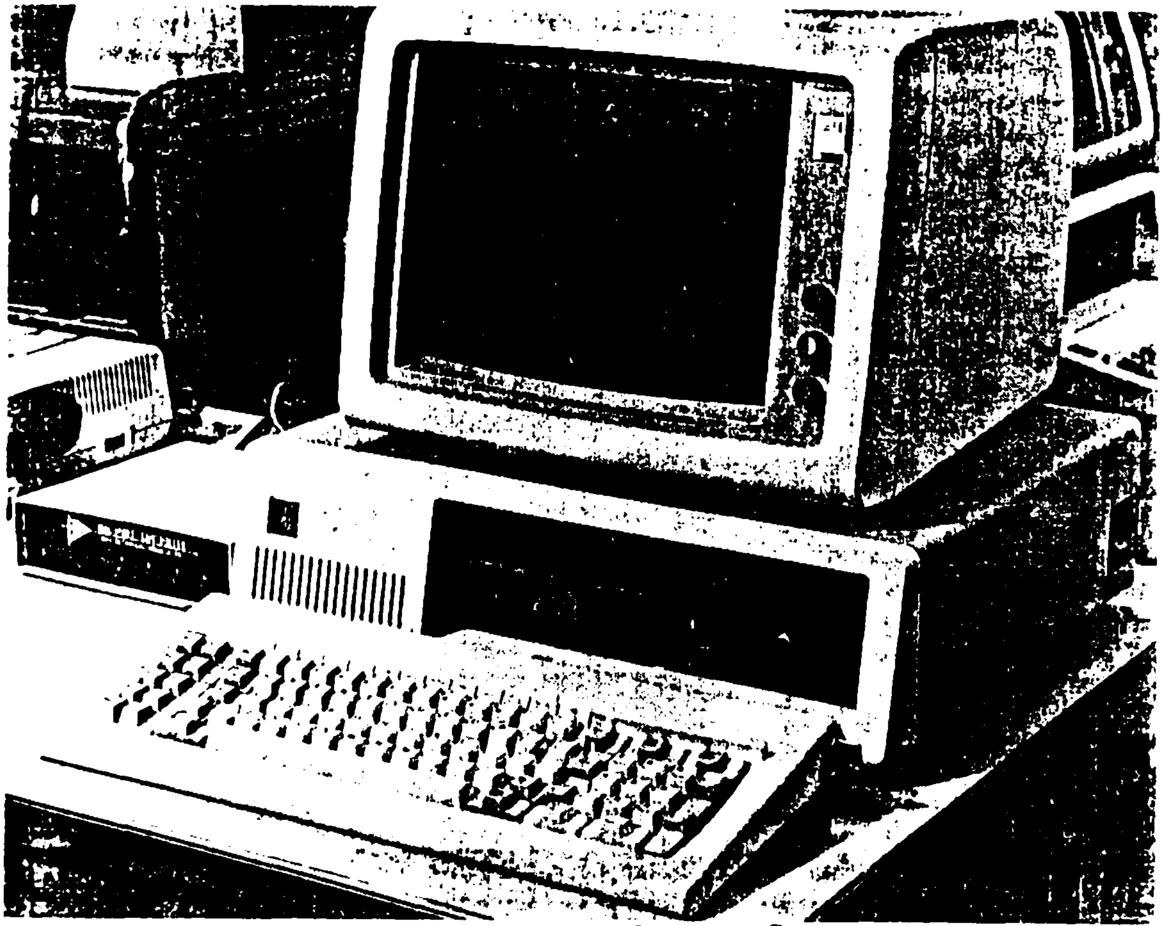


Fig. 9 - IBM PC-XT Host Computer System

Under the present configuration, one process control computer is used for controlling each machine. Each Apple computer was configured with 48K or main memory, 64-K ROM cards, and Microsoft Softcards to facilitate running the CP/M operating system, and a serial interface for communication with the IBM PC-XT host computer.

One of the six-axis stepper motor controllers with integral power supply is shown in Fig. 8. This unit is interfaced directly to the Apple II microcomputer process control system by means of a parallel interface cable.

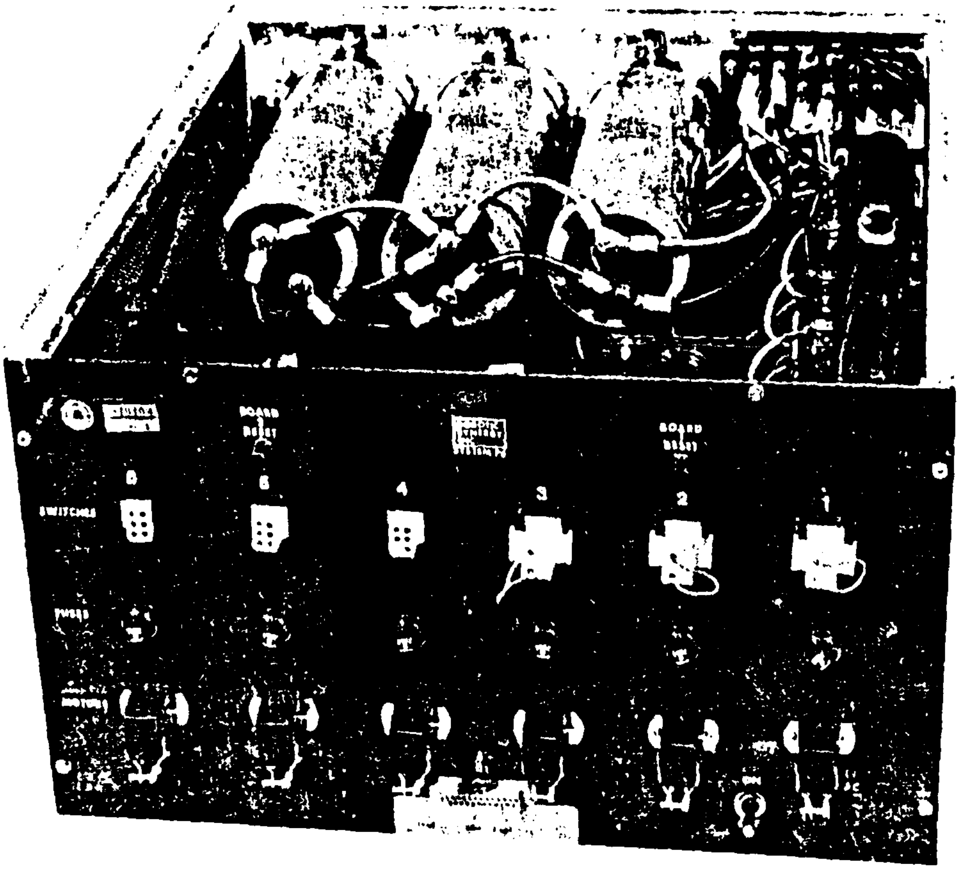


Fig. 8 - Six-axis Stepper Motor Controller and Power Supply

The stepper motor controller was built by Robotic Synergy of Salt Lake City. This controller contains the popular CY512 stepper motor control circuit. This circuit provides automatic acceleration and deceleration, allows various slewing rotes and provides synchronization input and output signals.

Some work still remains to be done on the robot manipulator to bring it to the desired level of positioning accuracy and to develop required interchangeable end-effectors needed to handle a variety of materials.

Some work was done in investigating various types of feed-back and adaptive control systems such as could be used with either stationary or mobile robots, but because of problems in getting the robot operational, these features have not been incorporated.

3.2 Computing and Control System Hardware

Designs were made and prototype equipment was fabricated or purchased to: (a) control the stepper motors used for positioning each of the various machine axes, (b) remotely control spindle drive motors, and (c) to perform required computations for design, planning, scheduling, and transfer of data between the host computers and process control computers.

3.2.1 Equipment Controllers

Each of the miniature machine tools is positioned by means of digital stepper motor drives attached to ball screws or to special cogged belts. These drives are in turn controlled by means of stepper motor drivers which act under direction of Apple II microcomputers which serve the function of process control computers.

One of the Apple II microcomputers is shown in Fig. 7 along with the Corvus winchester shared-disc system.

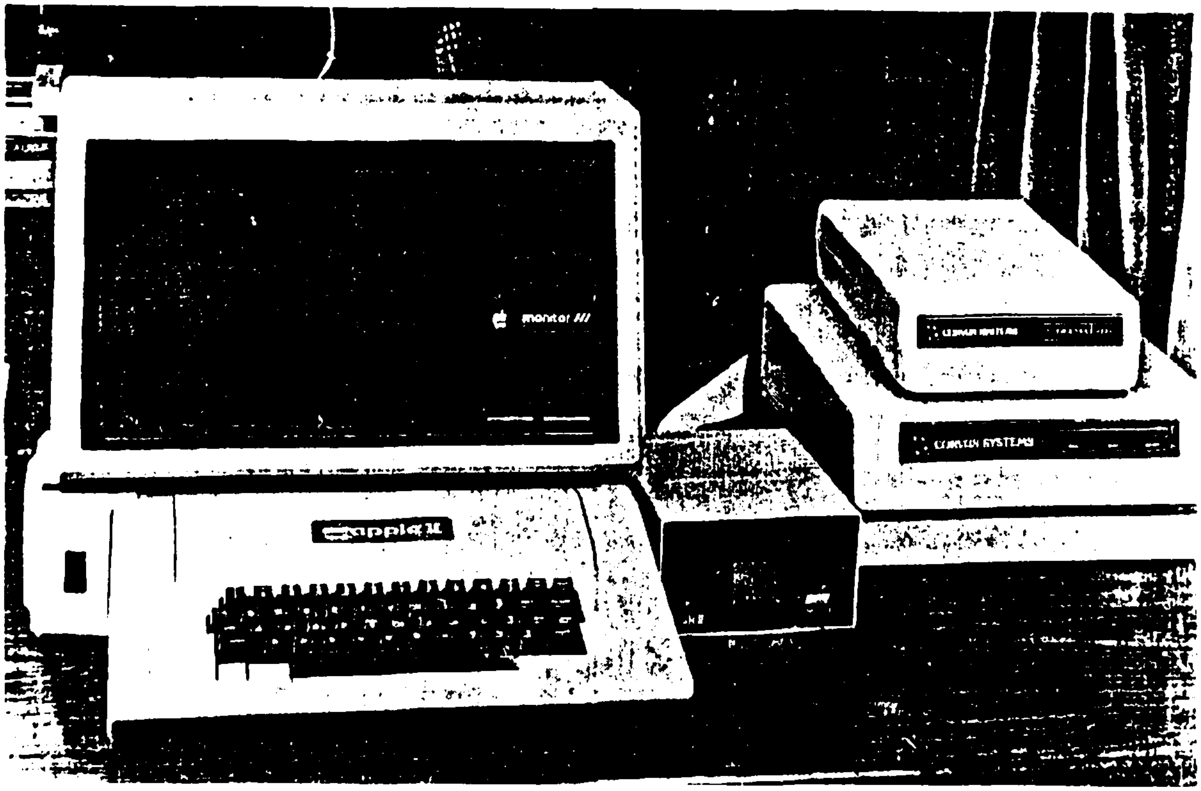


Fig. 7 - Process Control Computer and Shared Winchester Disc

station turret. An attempt was made to purchase the machine without a control unit but to no avail. The controller will be by-passed or removed as it is integrated into the manufacturing information system.

3.1.5 Industrial Robot Manipulator

As with the lathe, there was not a viable miniature robot available at the start of the project. Consequently, designs were made and a prototype unit was constructed. Original specifications for the five axis robot manipulator included:

a)	Lifting capacity	1 lb.
b)	Range	8" x 17"
c)	Positioning accuracy	± .005"
d)	Positioning rate	200 in/min

The robot is shown in Fig. 6 alongside other equipment to be used in developing the integrated manufacturing system and evaluating system performance under a range of operating conditions.

Detailed designs for the Industrial Robot Manipulator are contained in Appendix E.

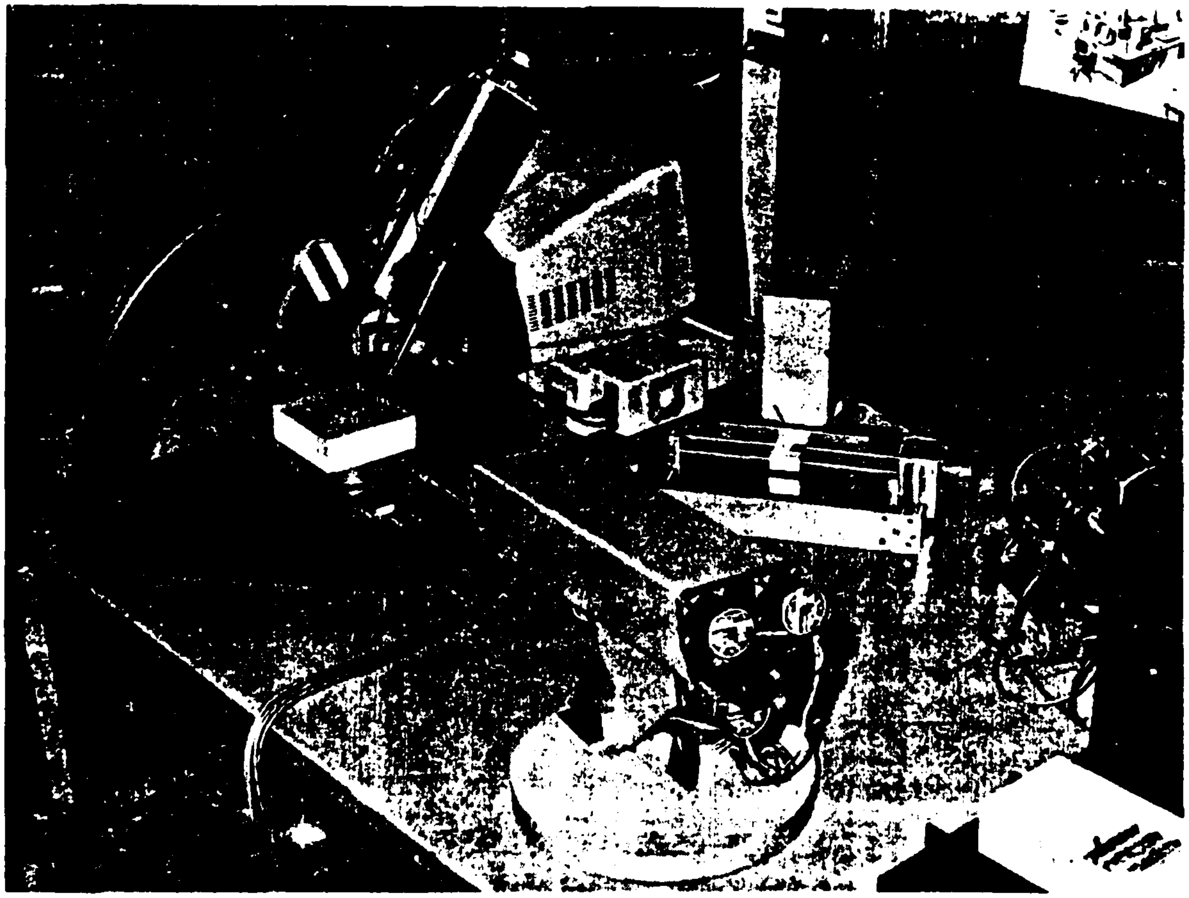
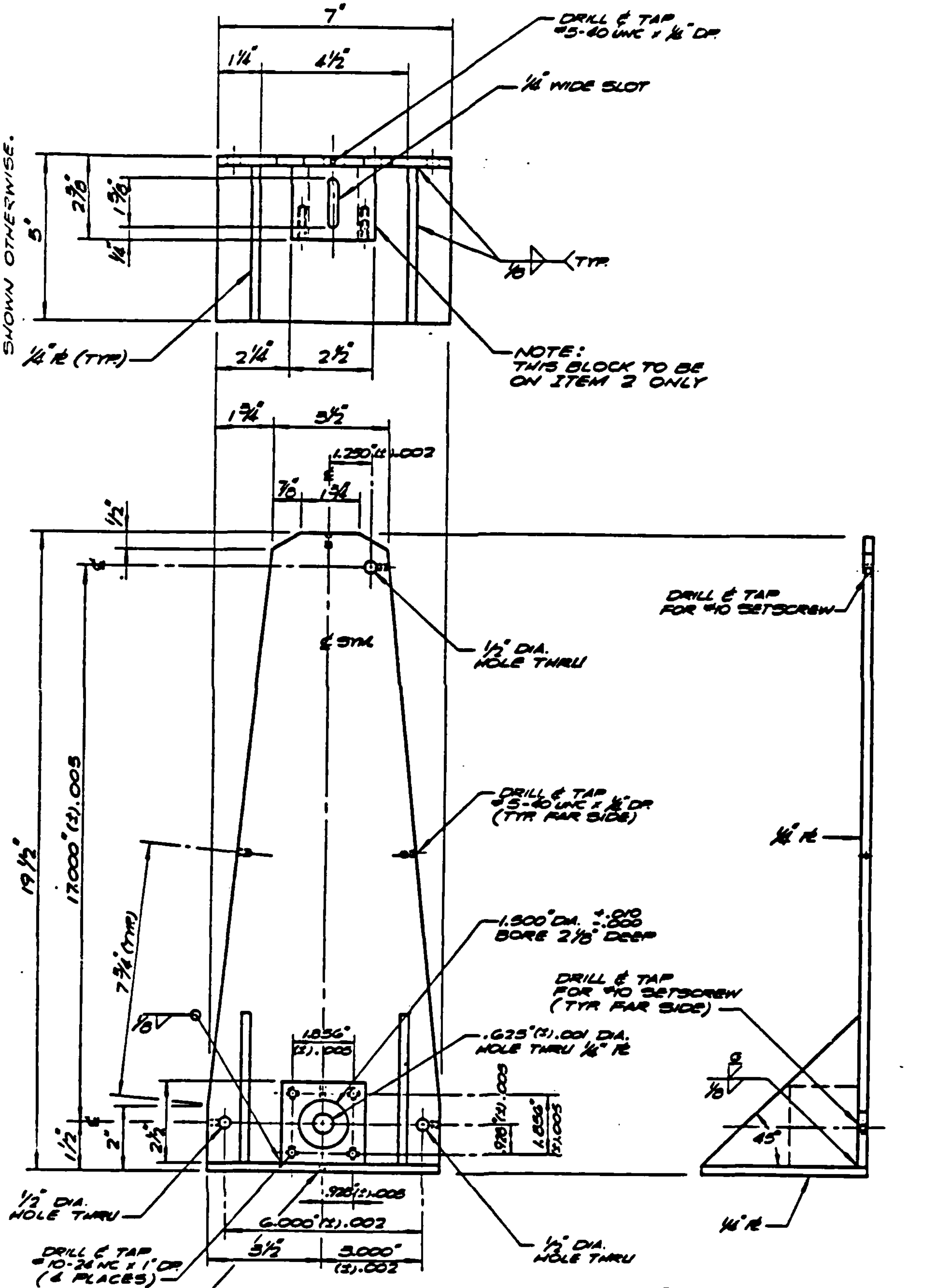


Fig. 6 - Industrial Robot Manipulator (Foreground)

NOTES

1 WORK THIS DWG. WITH BILL OF MATERIALS M00010.
2 ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3 ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

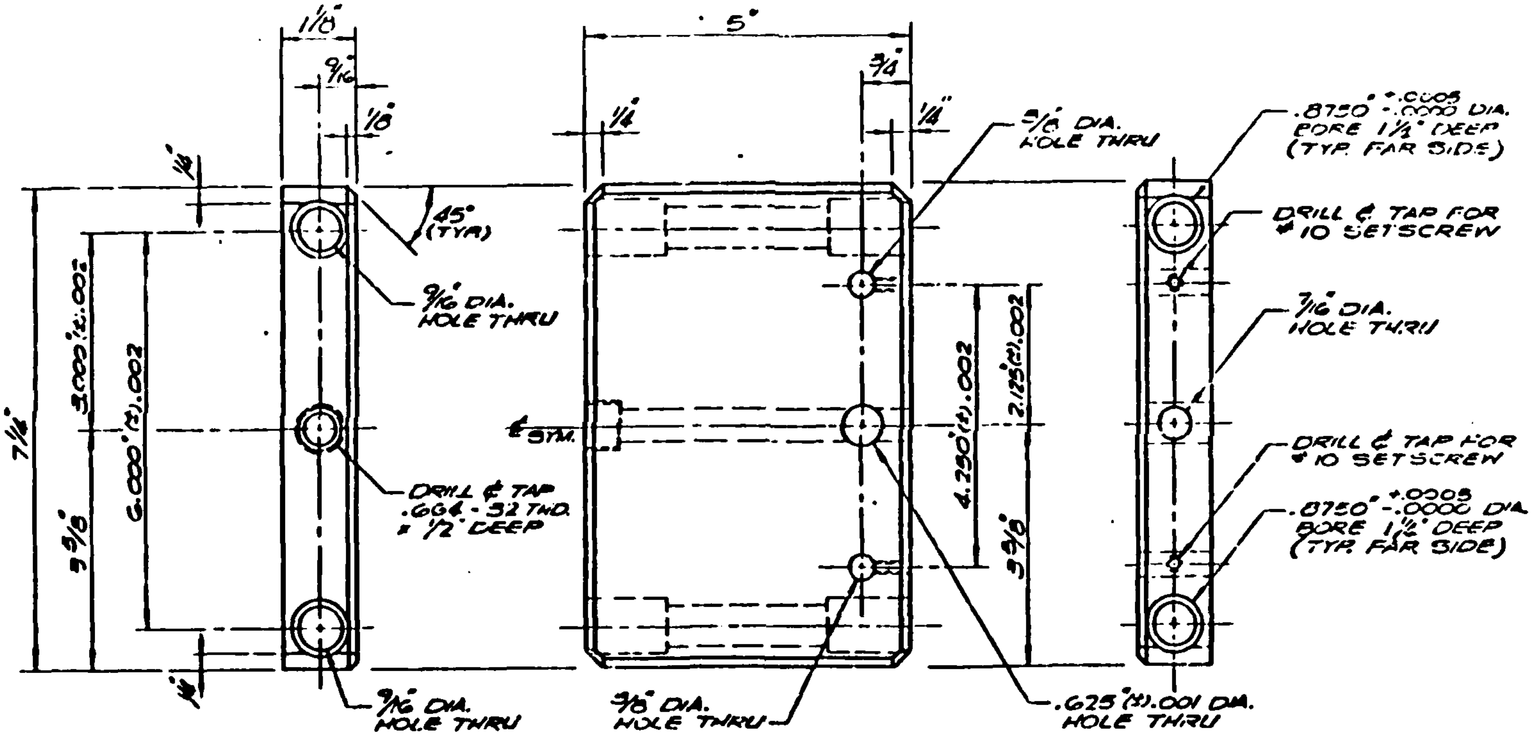

7"
1 1/4"
4 1/2"
DRILL & TAP #5-40 UNC × 1/4" DP.
1/4" WIDE SLOT
2 7/8"
1 5/8"
1/4"
5"
1/8
(TYP.
1/4" R (TYP.)
2 1/4"
2 1/2"
NOTE: THIS BLOCK TO BE ON ITEM 2 ONLY
1 3/4"
3 1/2"
1.250"(±).002
7/8"
1 3/4
1/2"
℄ SYM.
1/2" DIA. HOLE THRU
DRILL & TAP FOR #10 SETSCREW
19 1/2"
17.000"(±).005
DRILL & TAP #5-40 UNC × 1/4" DP. (TYP. FAR SIDE)
1/4" R
7 3/4" (TYP.)
1.500" DIA. +.010 -.000 BORE 2 1/8" DEEP
DRILL & TAP FOR #10 SETSCREW (TYP. FAR SIDE)
1/8
1.856" (±).005
.625"(±).001 DIA. HOLE THRU 1/4" R
.928"(±).003
1.856" (±).005
6
1/8
45°
1 1/2"
2"
2 1/2"
1/2" DIA. HOLE THRU
.928"(±).003
6.000"(±).002
3 1/2
3.000" (±).002
1/4" R
1/2" DIA. HOLE THRU
DRILL & TAP #10-24 NC × 1" DP. (4 PLACES)
DRILL & TAP #5-40 UNC × 1/4" DP.

DETAIL ITEM (2) C. STEEL (AS SHOWN)
SCALE: 1/2"=1"

DETAIL ITEM (3) C. STEEL (SIMILAR EXCEPT AS NOTED)
SCALE: 1/2"=1"

NOTES

1. WORK THIS DWG. WITH BILL OF MATERIALS MC010.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.



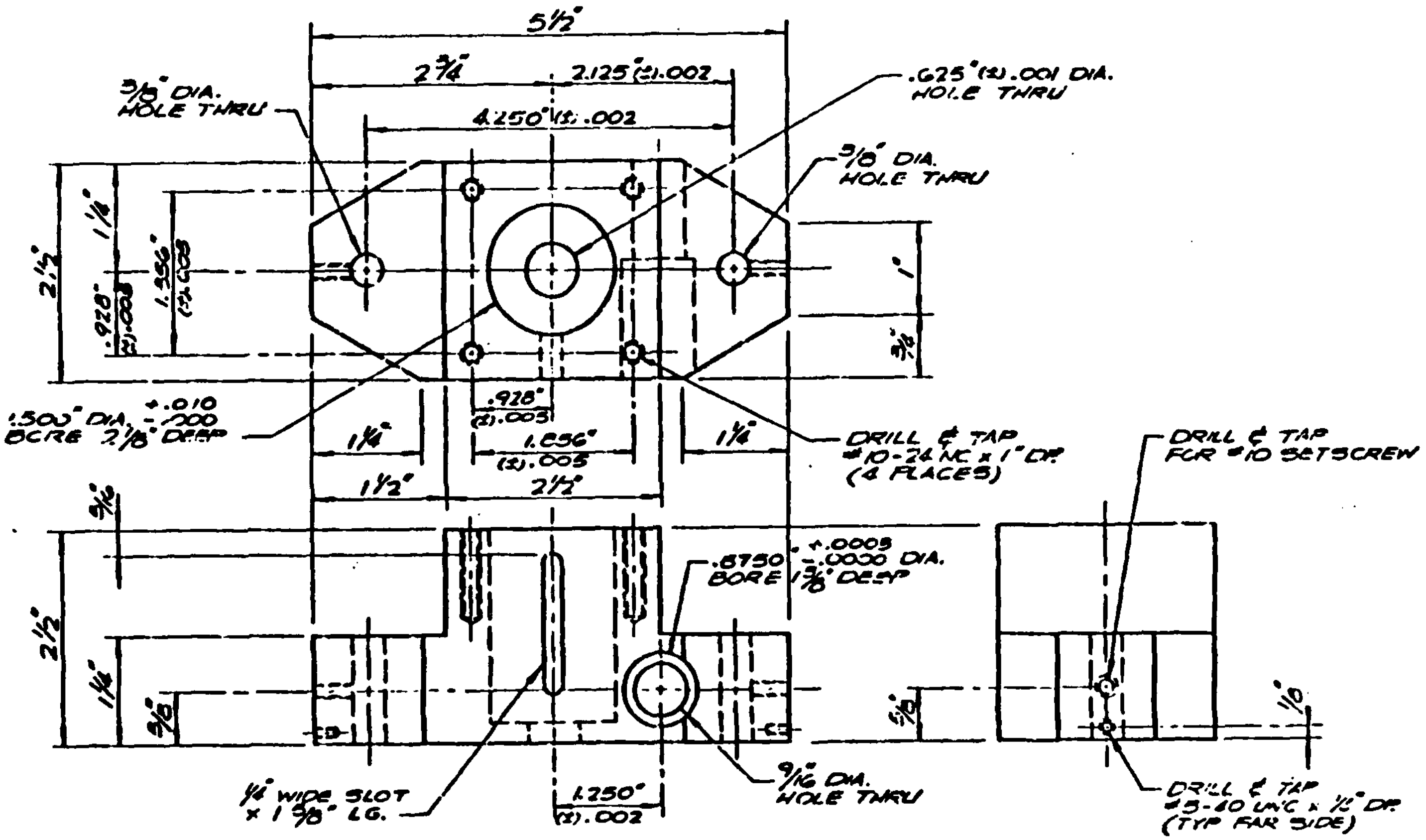
1 1/8"
9/16"
1/8"
5"
3/4"
1/4"
1/4"
45° (TYP.)
9/16" DIA. HOLE THRU
DRILL & TAP .664-32 THD. x 1/2" DEEP
9/16" DIA. HOLE THRU
7 1/4"
3.000"(±).002
6.000"(±).002
3 5/8"
℄ SYM.
5/16" DIA. HOLE THRU
9/16" DIA. HOLE THRU
.625"(±).001 DIA. HOLE THRU
4.250"(±).002
2.125"(±).002
3 5/8"
.8750" +.0005 -.0000 DIA. BORE 1 1/2" DEEP (TYP. FAR SIDE)
DRILL & TAP FOR #10 SETSCREW
7/16" DIA. HOLE THRU
DRILL & TAP FOR #10 SETSCREW
.8750" +.0005 -.0000 DIA. BORE 1 1/2" DEEP (TYP. FAR SIDE)

DETAIL ITEM (4) (ALUMINUM)

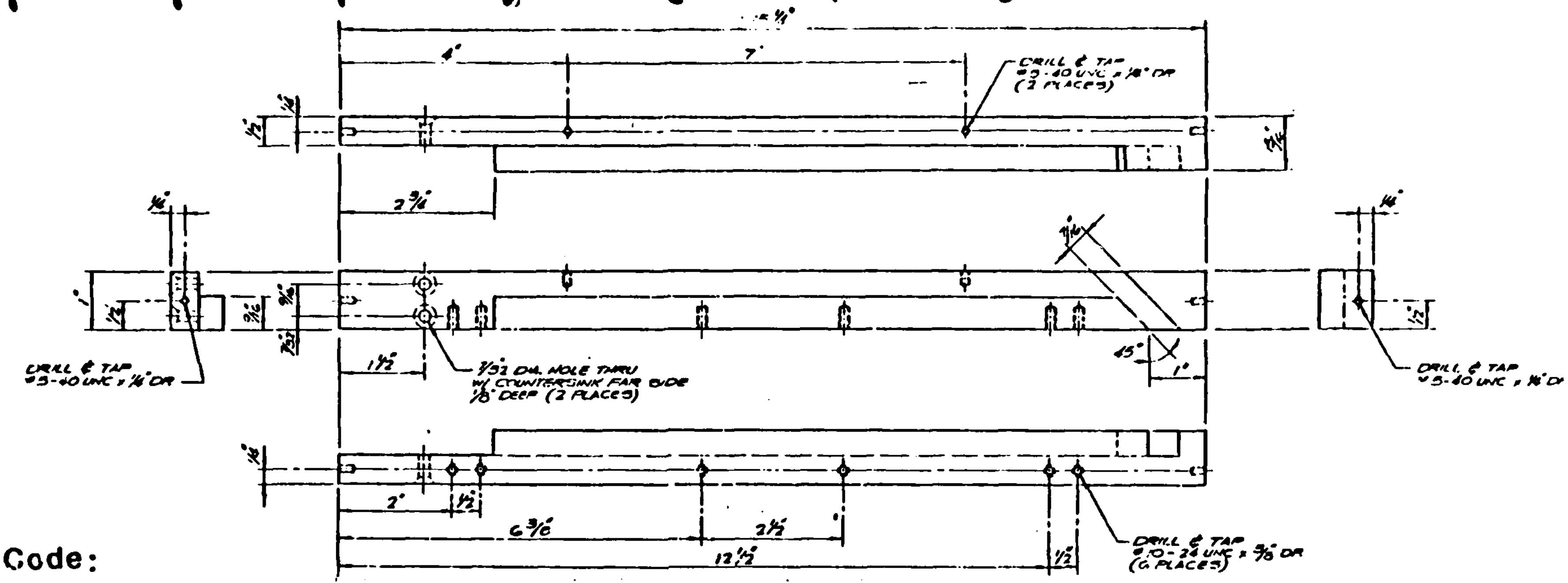
SCALE: 5/8" = 1"

NOTES

1. WORK THIS DWG. WITH BILL OF MATERIALS M0010.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.



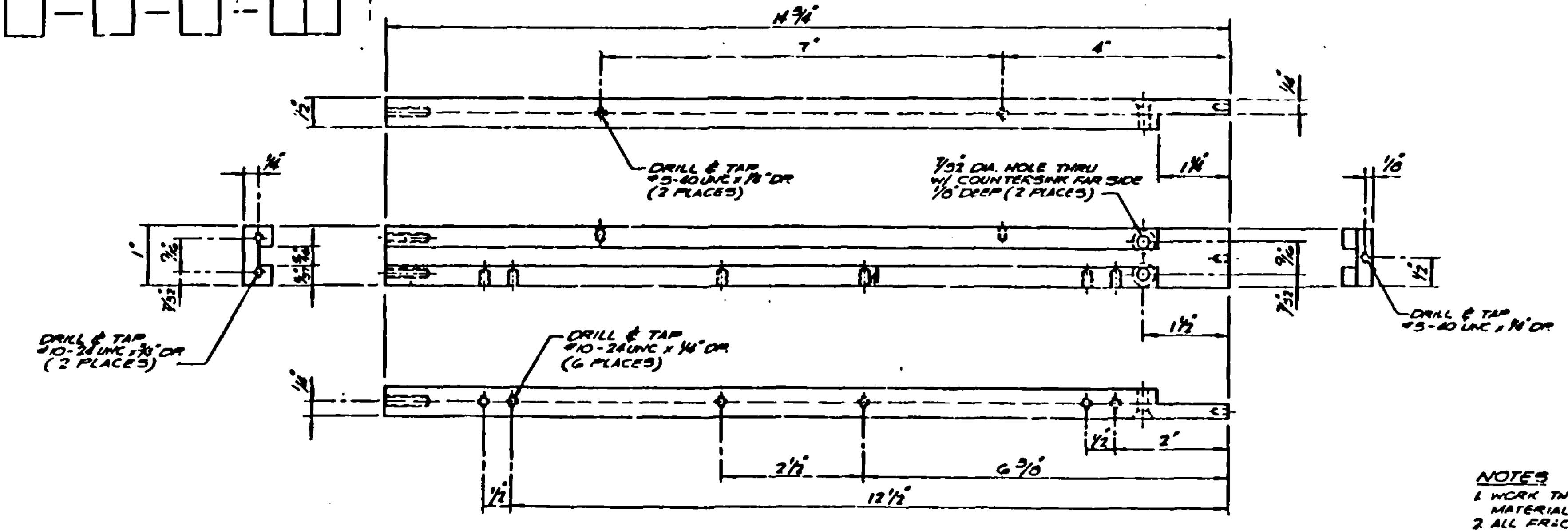
DETAIL ITEM (5) (ALUMINUM)
SCALE: FULL


11 3/4"
4"
7"
DRILL & TAP #5-40 UNC x 1/8" DP (2 PLACES)
1/2"
1/16"
3/4"
2 3/16"
1/16"
1"
1/2"
9/16"
7/32"
DRILL & TAP #5-40 UNC x 1/4" DP
1 1/2"
7/32" DIA. HOLE THRU w/ COUNTERSINK FAR SIDE 1/8" DEEP (2 PLACES)
1/16"
45°
1"
1/16"
1/2"
DRILL & TAP #5-40 UNC x 1/4" DP
1/16"
2"
1/2"
6 3/8"
2 1/2"
12 1/2"
1/2"
DRILL & TAP #10-24 UNC x 3/8" DP (6 PLACES)

DETAIL ITEM 6 (ALUMINUM)
SCALE: FULL

Part Family Code:

BASIC SHAPE	FORM FEATURES	SIZE	PRECISION	MATERIAL
□□□ —	□ —	□ —	□ —	□□

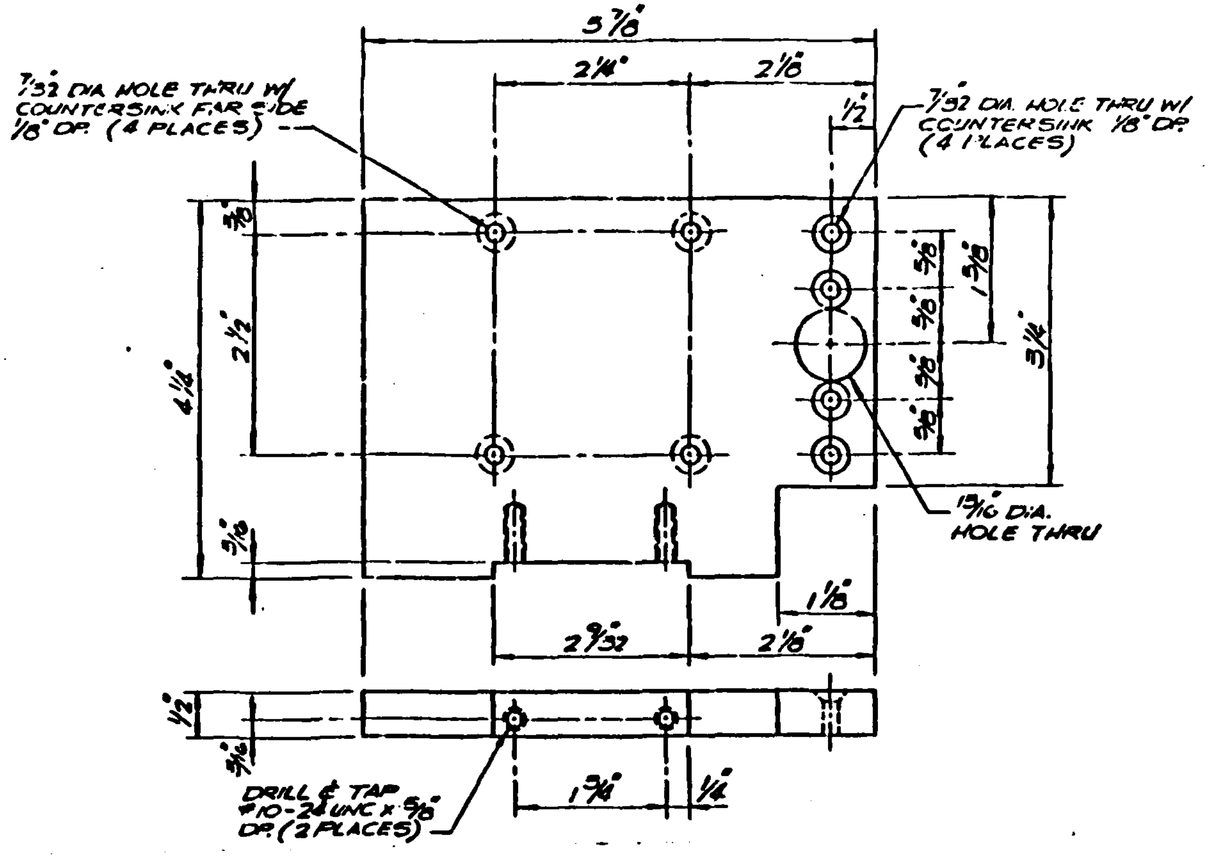

11 3/4"
7"
4"
1/2"
1/16"
DRILL & TAP #5-40 UNC x 1/8" DP (2 PLACES)
7/32" DIA. HOLE THRU w/ COUNTERSINK FAR SIDE 1/8" DEEP (2 PLACES)
1 1/16"
1/16"
1/8"
1"
9/16"
7/32"
9/16"
1/2"
7/32"
DRILL & TAP #5-40 UNC x 1/4" DP
1 1/2"
DRILL & TAP #10-24 UNC x 3/8" DP (2 PLACES)
DRILL & TAP #10-24 UNC x 1/4" DP (6 PLACES)
1/16"
1/2"
2"
2 1/2"
6 3/8"
1/2"
12 1/2"

DETAIL ITEM 7 (ALUMINUM)
SCALE: FULL

NOTES
1. WORK THIS D
MATERIALS M
2. ALL FRACTION
TO BE (±) 1/
3. ALL HOLE SI
ACTUAL DRILL
SHOWN OTH

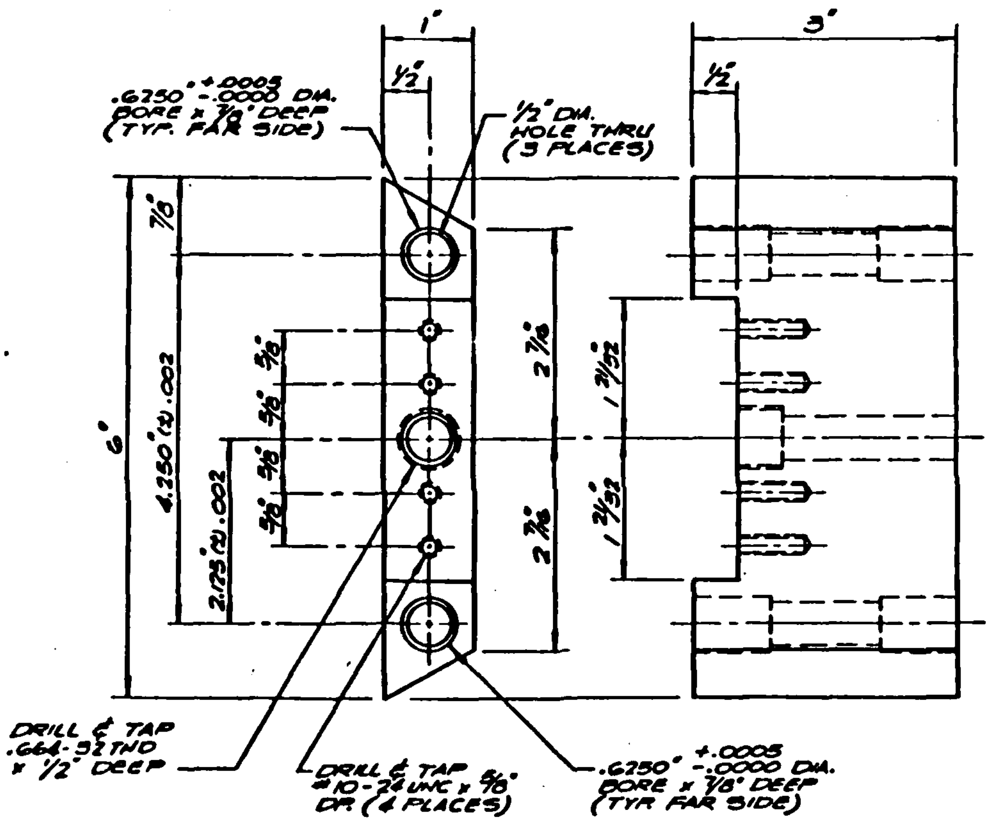
ER 22, 1981	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	MINI - STACKER	DETAIL ITEM 6 & 7	[illegible]

NOTES
1. WORK THIS DWG. WITH BILL OF MATERIALS M0010 & DWG 0011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.


5 7/8"
2 1/4"
2 1/8"
1/2"
7/32" DIA HOLE THRU W/ COUNTERSINK FAR SIDE 1/8" DP. (4 PLACES)
7/32" DIA. HOLE THRU W/ COUNTERSINK 1/8" DP. (4 PLACES)
3/8"
2 1/2"
4 1/4"
3/16"
5/8"
5/8"
5/8"
5/8"
1 5/8"
3 1/4"
13/16" DIA. HOLE THRU
1 1/8"
2 9/32"
2 1/8"
1/2"
3/16"
1 3/4"
1/4"
DRILL & TAP #10-24 UNC x 5/8" DP. (2 PLACES)

DETAIL ITEM (8) (ALUMINUM)
SCALE: FULL

NOTES
1. WORK THIS DWG. WITH BILL OF MATERIALS M0010 & DWG 0011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

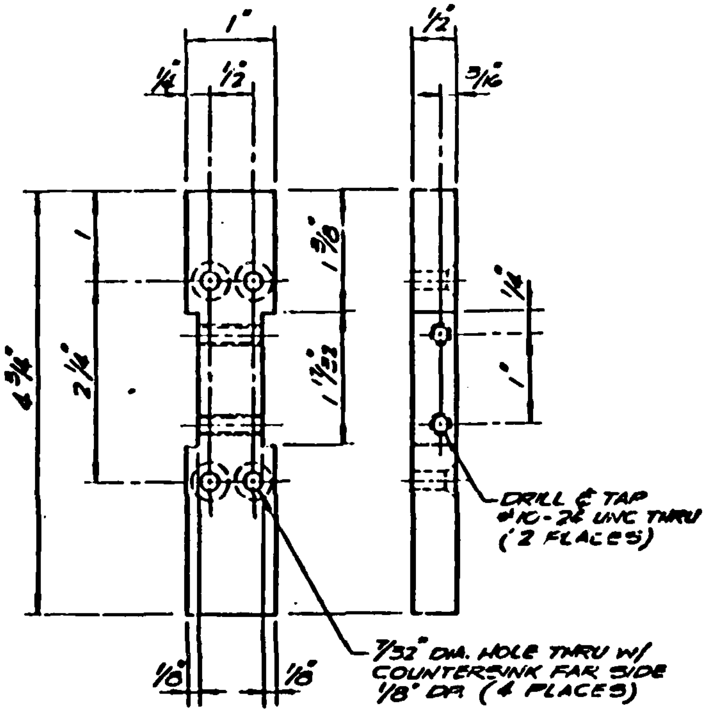

1"
1/2"
3"
1/2"
.6250" +.0005 -.0000 DIA. BORE x 7/8" DEEP (TYP. FAR SIDE)
1/2" DIA. HOLE THRU (3 PLACES)
7/8"
6"
4.250"(±).002
2.125"(±).002
5/8"
5/8"
5/8"
5/8"
2 7/16"
2 7/16"
1 21/32"
1 21/32"
DRILL & TAP .664-32 THD x 1/2" DEEP
DRILL & TAP 5/16" #10-24 UNC x 5/8" DP. (4 PLACES)
.6250" +.0005 -.0000 DIA. BORE x 7/8" DEEP (TYP. FAR SIDE)

DETAIL ITEM 9 (ALUMINUM)

SCALE: FULL

NOTES

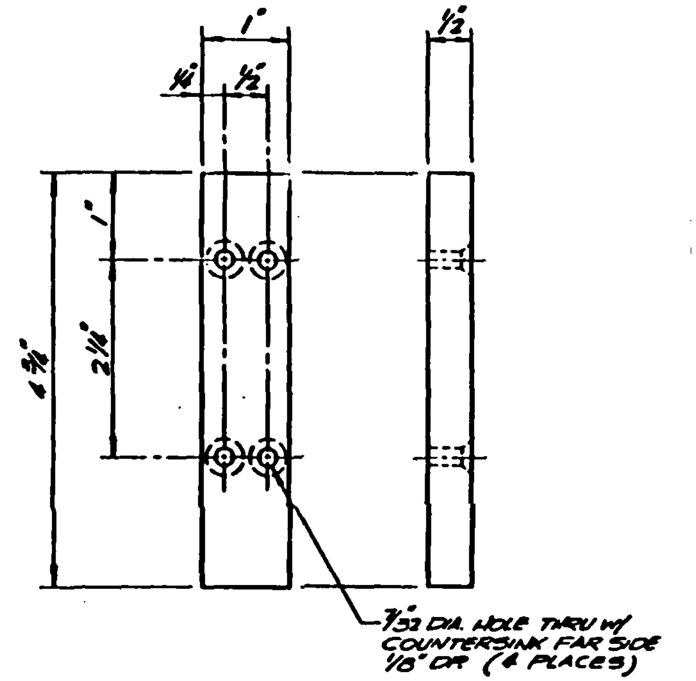
1. WORK THIS DWG WITH BILL OF MATERIALS M0010 & DWG 0011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.


1"
1/4"
1/2"
1/2"
3/16"
4 3/4"
1
2 1/4"
1 3/16"
1 17/32"
1/16"
1"
1/8"
1/8"
DRILL & TAP #10-24 UNC THRU (2 PLACES)
7/32" DIA. HOLE THRU W/ COUNTERSINK FAR SIDE 1/8" DP. (4 PLACES)

DETAIL ITEM (10) (ALUMINUM)
SCALE: FULL

NOTES

1. WORK THIS DWG. WITH BILL OF MATERIALS M0010 & DWG 0011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

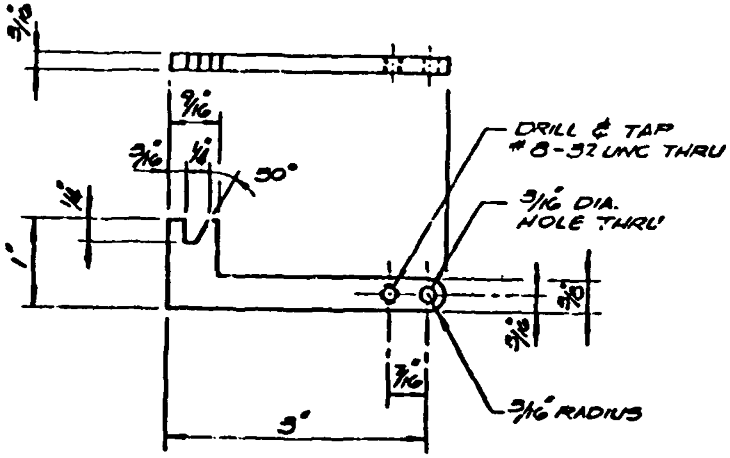


DETAIL ITEM (11) (ALUMINUM)

SCALE: FULL

NOTES

1. WORK THIS DWG. WITH BILL OF MATERIALS M0010 & DWG C011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

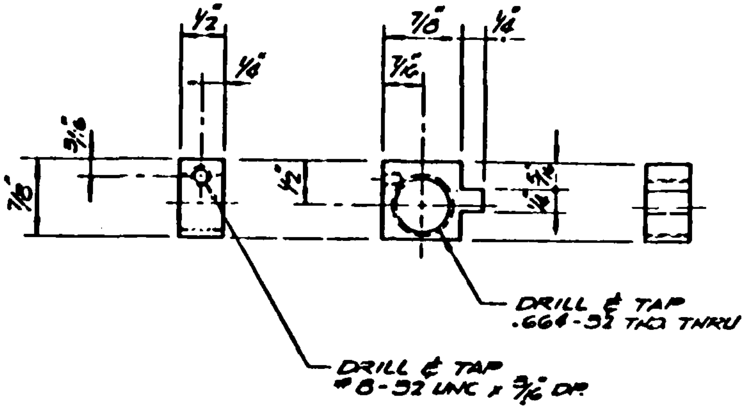


DETAIL ITEM (12) (ALUMINUM)

SCALE: FULL

NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS MCUIC & DWG OC'1.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.



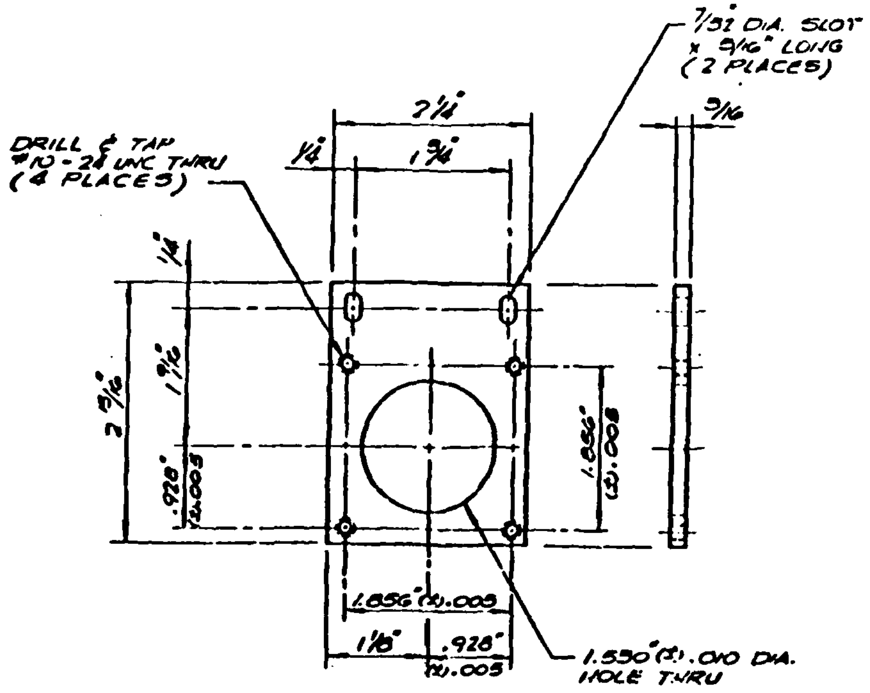
1/2"
1/8"
7/8"
1/4"
7/16"
9/16"
7/8"
1/2"
5/16"
1/4"
DRILL & TAP .664-32 THD THRU
DRILL & TAP #8-32 UNC x 3/16" DP.

DETAIL ITEM (13) (ALUMINUM)

SCALE: FULL

NOTES:

1. WORK THIS DWG WITH BILL OF MATERIALS 1AC010 & DWG CCI.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

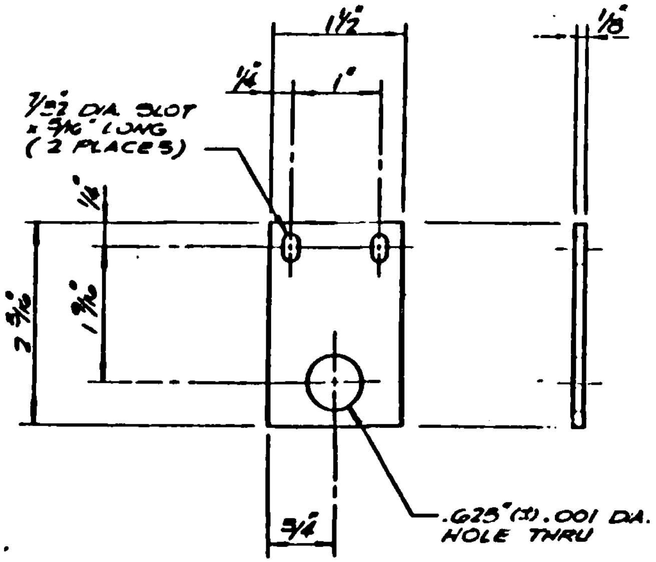

DRILL & TAP #10-24 UNC THRU (4 PLACES)
7/32" DIA. SLOT x 9/16" LONG (2 PLACES)
2 1/4"
1/4"
1 3/4"
5/16
1/4"
2 13/16"
1 9/16"
.928" (±).005
1.856" (±).008
1.856" (±).005
1 1/8"
.928" (±).005
1.550" (±).010 DIA. HOLE THRU

DETAIL ITEM (14) (ALUMINUM)

SCALE: FULL

NOTES:

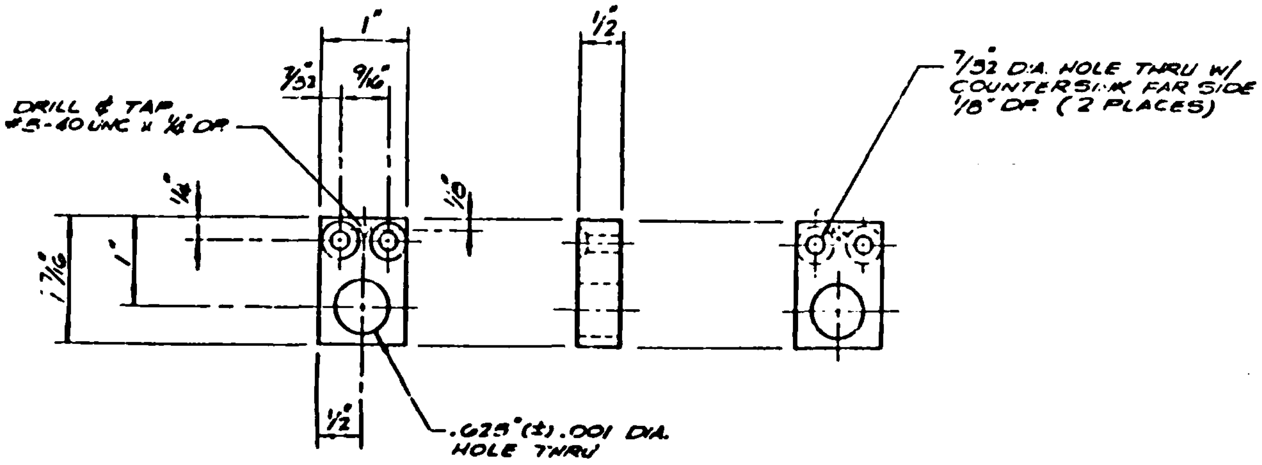
1. WORK THIS DWG WITH BILL OF MATERIALS M0010 & DWG 0011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.



DETAIL ITEM (15) (ALUMINUM)
SCALE: FULL

NOTES:

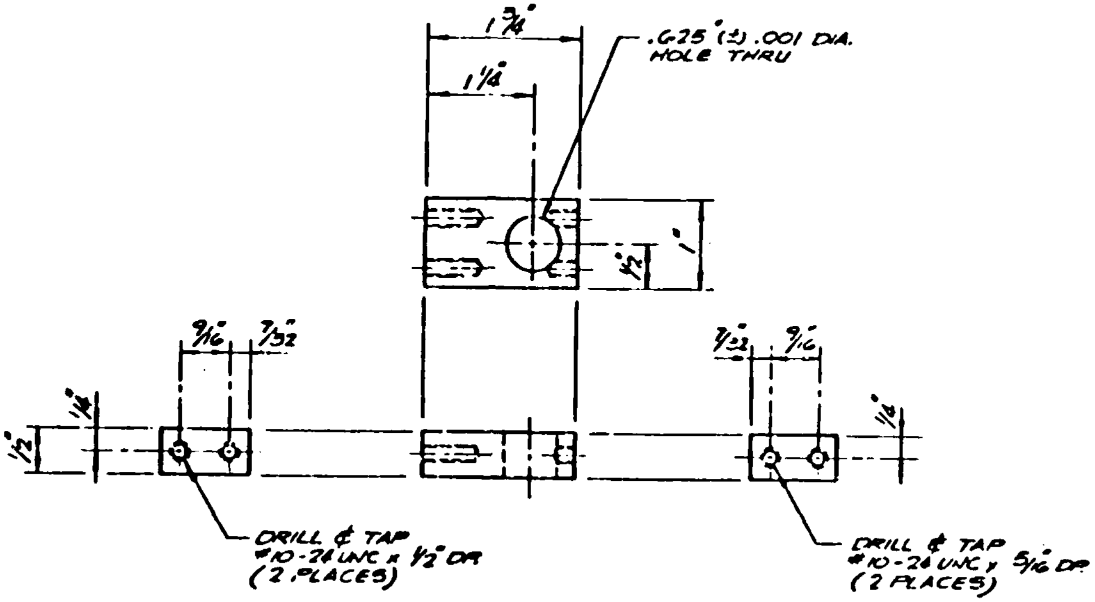
1. WORK THIS DWG WITH BILL OF MATERIALS M0010 & DWG 0011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.


1"
7/32"
9/16"
1/2"
DRILL & TAP #5-40 UNC x 1/4" DP
1/4"
1/8"
1 7/16"
1"
1/2"
.625"(±).001 DIA. HOLE THRU
7/32" DIA. HOLE THRU W/ COUNTERSINK FAR SIDE 1/8" DP (2 PLACES)

DETAIL ITEM (16) (ALUMINUM)

SCALE: FULL

1. WORK THIS DWG WITH BILL OF MATERIALS M0010 & DWG C011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.


1 3/4"
1 1/4"
.625" (±) .001 DIA. HOLE THRU
1"
1/2"
9/16"
7/32"
1/16"
1/2"
7/32"
9/16"
1/16"
DRILL & TAP #10-24 UNC x 1/2" DP (2 PLACES)
DRILL & TAP #10-24 UNC x 5/16" DP (2 PLACES)

DETAIL ITEM (17) (ALUMINUM)
SCALE: FULL

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY		Project No	Drawing No M0001	Sheet 2 of 9
Prepared by FORREST BLAIR	Date 7-10-81	REVISIONS NO.	DESCRIPTION	DATE
Approved by	Date			
Project Engineer	Date			
Project Name CAD-CAM				
Drawing Title TURRET PUNCH				

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
11	0007	Punch Retainer Clip	8	C. Steel	
12	0007	Plunger	1	C. Steel	
13	0007	Punch	8	C. Steel	
14	0007	Die Plate	8	C. Steel	
15	0008	Carriage Screw	1	See Detail	
16	0008	Transverse Screw	1	See Detail	
17	0008	Carriage Support Rod	2	C. Steel	
18	0008	Transverse Support Rod	2	C. Steel	
19	0008	Washer	1	Nylon	
20	0008	Drive Gear	1	See Detail	
21	0008	Bearing Clamp	1	Aluminum	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY		Project No	Drawing No M0001	Sheet 3 of 9
Prepared by FORREST BLAIR	Date 7-10-81	REVISIONS NO.	DESCRIPTION	DATE
Approved by	Date			
Project Engineer	Date			
Project Name CAD-CAM				
Drawing Title TURRET PUNCH				

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
22	0009	Lower Material Clamp	1	C. Steel	
23	0009	Upper Material Clamp	1	C. Steel	
24	0009	Cover	1	C. Steel	
				Or Equal	
25	0001 & 2	Motor-stepping, Model No. M091	2	Mfg. Std.	
				Slo-Syn	
26	0001	Motor-stepping, Model No. M061	2	Mfg. Std.	
				Slo-Syn	
27	0001 & 2	Solenoid - Heavy Duty AC,	1	Mfg. Std.	
		NA-700 Push Type, 1" Stroke,		Trombetta	
		Model No. NA-733-A1			
28	0001 & 2	Solenoid - Tubular Push Type,	1	Mfg. Std.	
		Model No. P8-1L, 12V D.C.		Dormeyer	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BRIGHAM YOUNG UNIVERSITY

CAD-CAM DEPT.

BILL OF MATERIALS

PROJECT TURRET FUNCH (M0001)

DRAWING NO.	DESCRIPTION
0001	ASSEMBLY-PLAN
0002	ASSEMBLY-SECTION
0003	DETAIL ITEM 1
0004	DETAIL ITEM 2
0005	DETAIL ITEM 3
0006	DETAIL ITEM 4, 5, 6, & 7
0007	DETAIL ITEM 8, 9, 10, 11, 12, 13, & 14
0008	DETAIL ITEM 15, 16, 17, 18, 19, 20, & 21
0009	DETAIL ITEM 22, 23, & 24

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY		Project No.	Drawing No. M0001 / Sheet 1 of 3
Prepared by FORREST BLAIR	Date 7-10-81		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title TURRET FUNCH			

REVISIONS		
NO.	DESCRIPTION	DATE

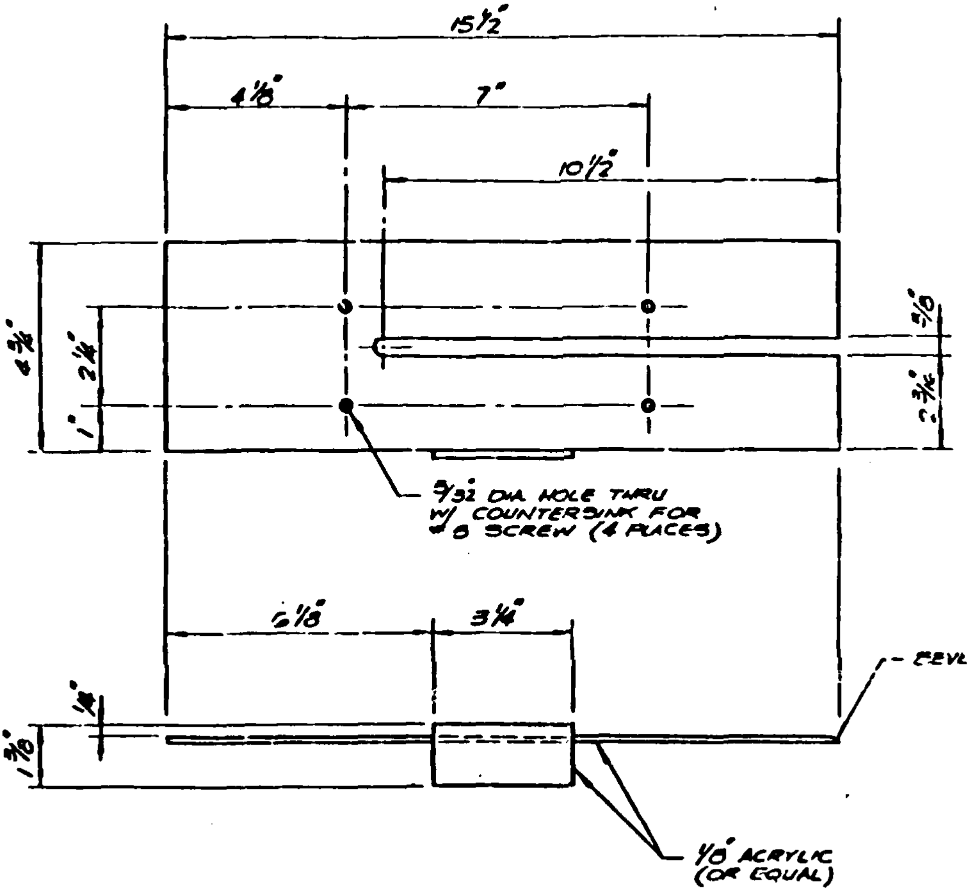
ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED		MATERIAL	DATE
	0001 & 2	Turret Punch Assembly	1	*		
1	0003	Table		1	C. Steel	
2	0004	Upper Punch Frame		1	C. Steel	
3	0005	Lower Punch Frame		1	C. Steel	
4	0006	Carriage Block		1	Aluminum	
5	0006	Carriage Motor Block		1	Aluminum	
6	0006	Carriage Support Block		1	Aluminum	
7	0006	Transverse Motor Block		1	Aluminum	
8	0007	Upper Turret Gear		1	See Detail	
9	0007	Lower Turret Gear		1	See Detail	
10	0007	Punch Guide		3	C. Steel	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT

APPENDIX B

Detailed Design for the Miniature Sheet-metal Turret Punch

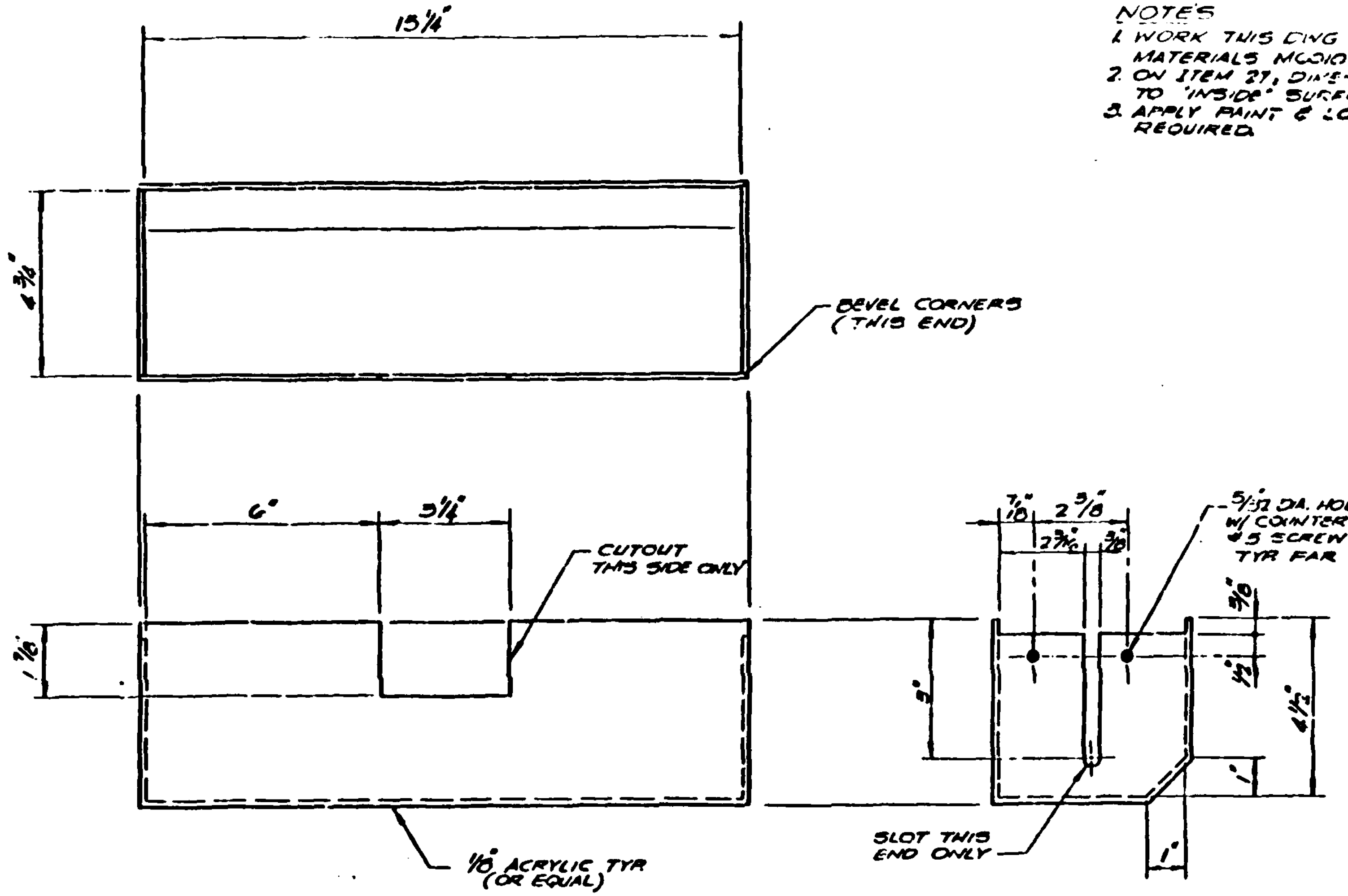
NOTES
1. WORK THIS DWG. WITH BILL OF MATERIALS MOO10 & DWG. OO11.
2. APPLY PAINT & LOGO AS REQUIRED.



DETAIL ITEM (78) (ACRYLIC OR EQUAL)
SCALE: ½"=1'-0

NOTES

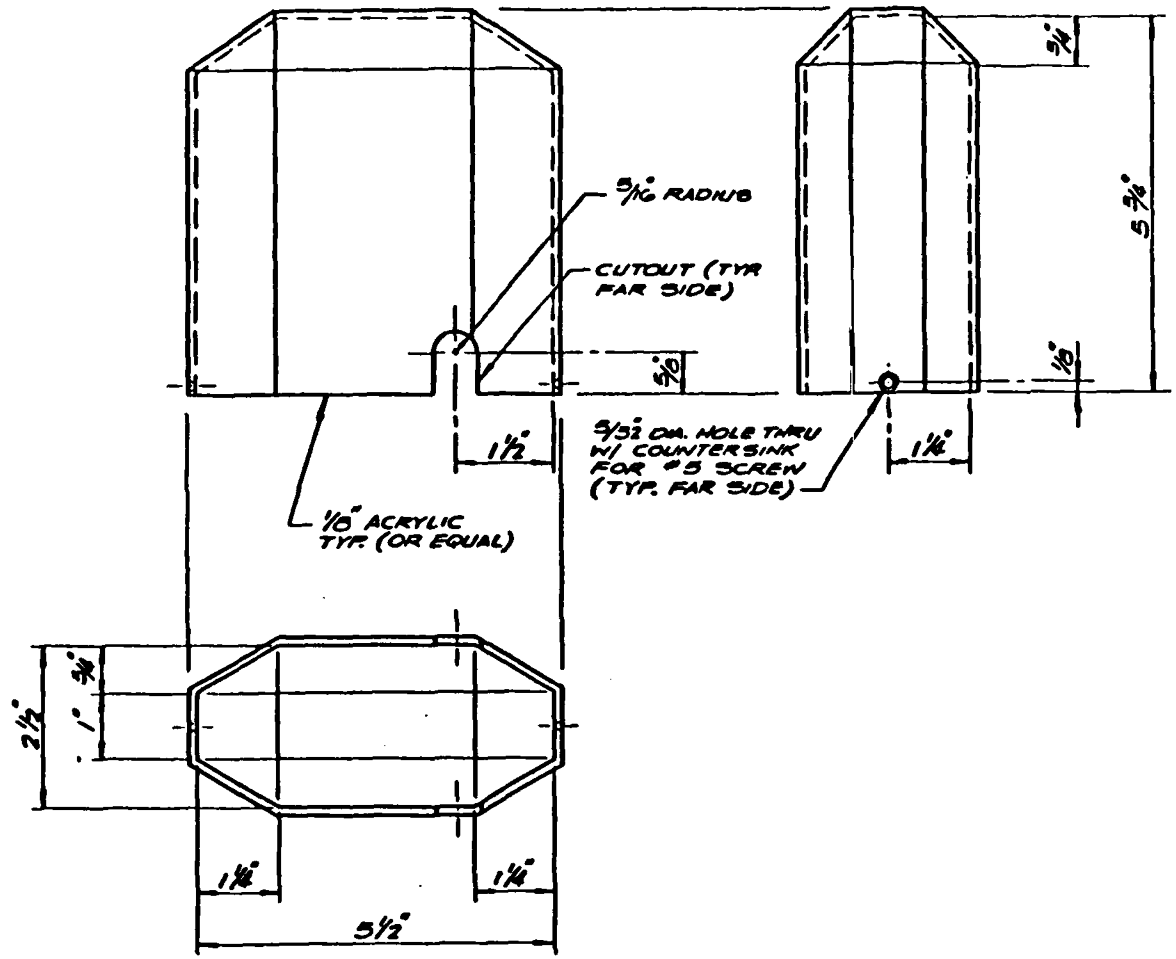
1. WORK THIS DWG WITH BILL OF MATERIALS MC010 & DWG 0011.
2. ON ITEM 27, DIMENSIONS ARE TO "INSIDE" SURFACE.
3. APPLY PAINT & LOGO AS REQUIRED.



DETAIL ITEM (27) (ACRYLIC OR EQUAL)
SCALE: ½" = 1'-0

NOTES

1. WORK THIS DWG. WITH BILL OF MATERIALS NO010 & DWG 0010.
2. ALL DIMENSIONS ARE TO "INSIDE" SURFACE.
3. APPLY PAINT & LOGO AS REQUIRED

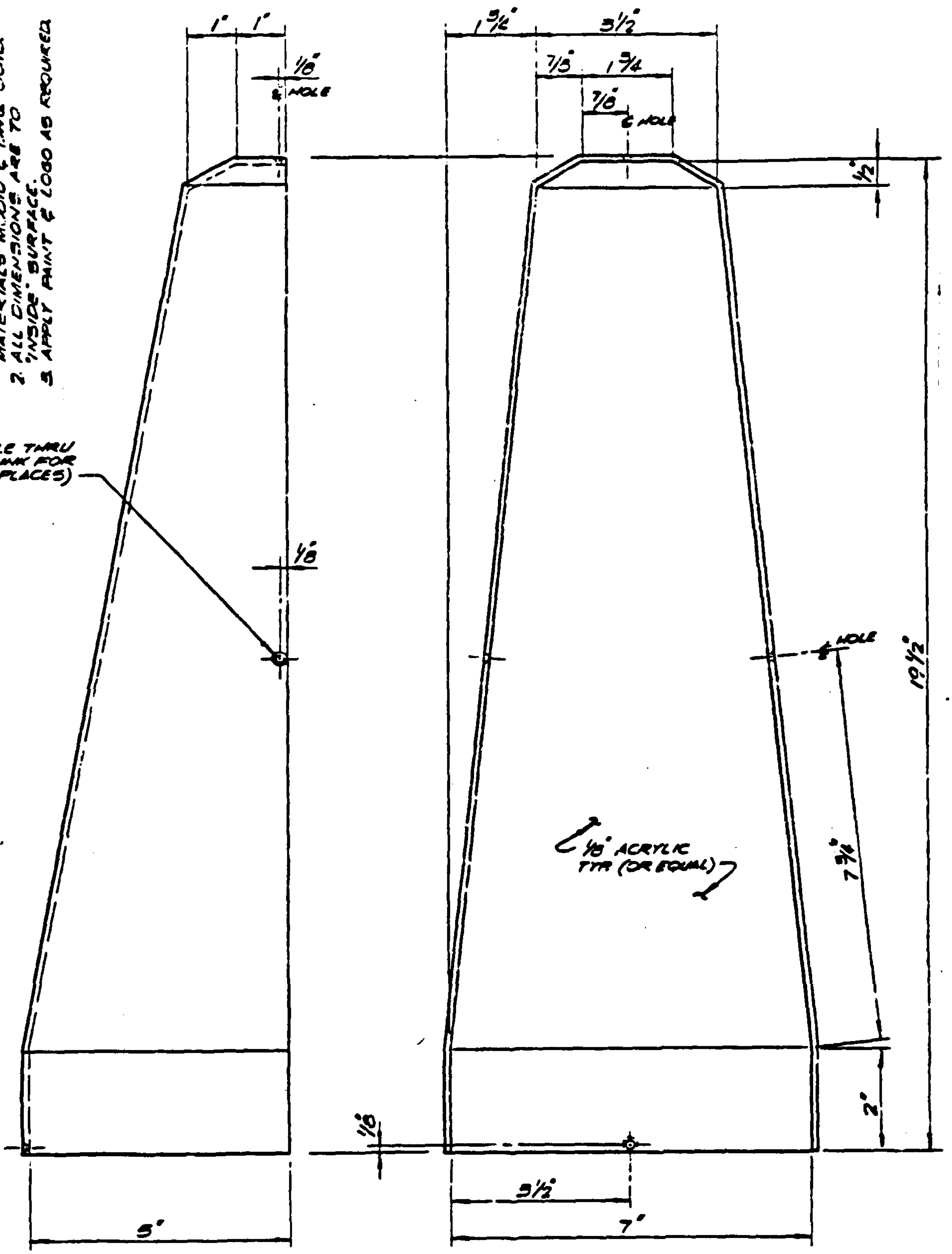


DETAIL ITEM 26 (ACRYLIC OR EQUAL)

SCALE: 3/4"=1'-0

NOTES

1. WORK THIS DWG. WITH BILL OF MATERIALS M0010 & DWG 0010
2. ALL DIMENSIONS ARE TO "INSIDE" SURFACE.
3. APPLY PAINT & LOGO AS REQUIRED

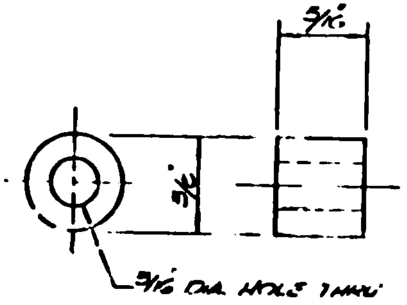


DETAIL ITEM 25 (ACRYLIC OR EQUAL)

SCALE: 3/4"=1'-0"

NOTES

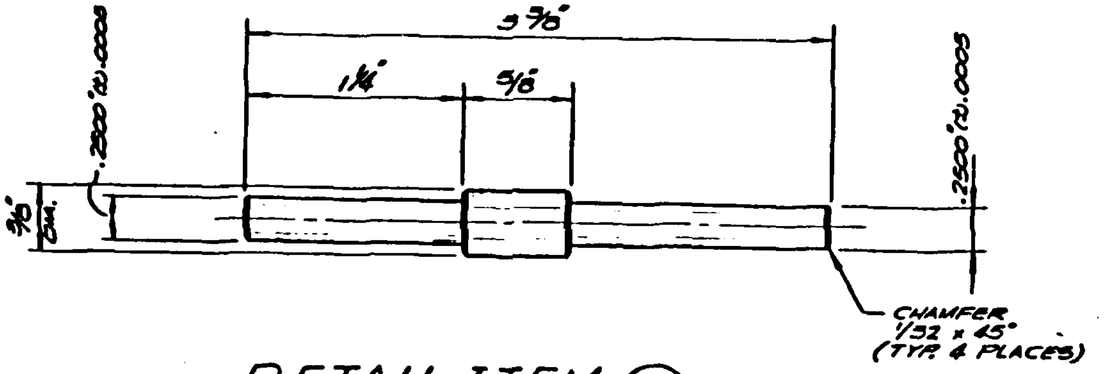
1. WORK THIS DWG WITH BILL OF MATERIALS Nº M0010 AND DWG. 0010 & 0011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".



DETAIL ITEM 24 (C. STEEL)
SCALE: 3"=1"

NOTES

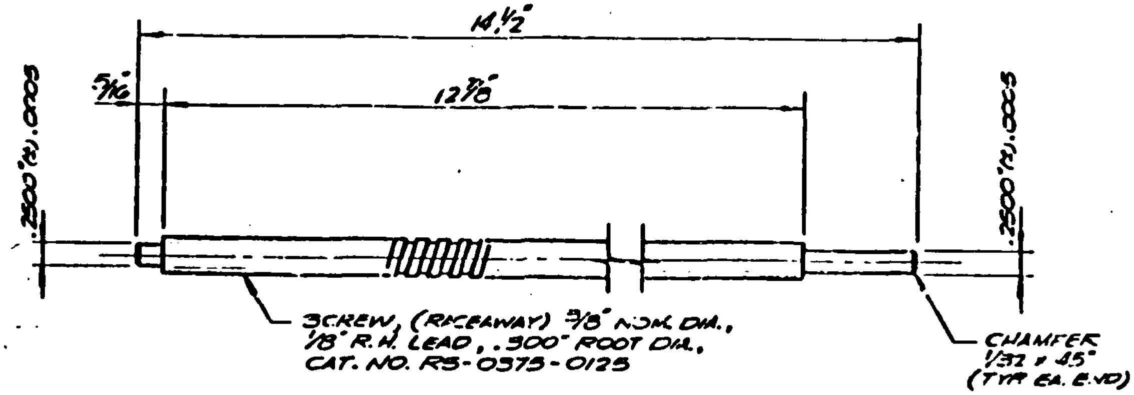
1. WORK THIS DWG WITH BILL OF MATERIALS Nº M0010 AND DWG. 0010 & 0011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".



DETAIL ITEM (23) (C. STEEL)
SCALE: 2"=1"

NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS Nº M0010 AND DWG. 0010 & 0011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".

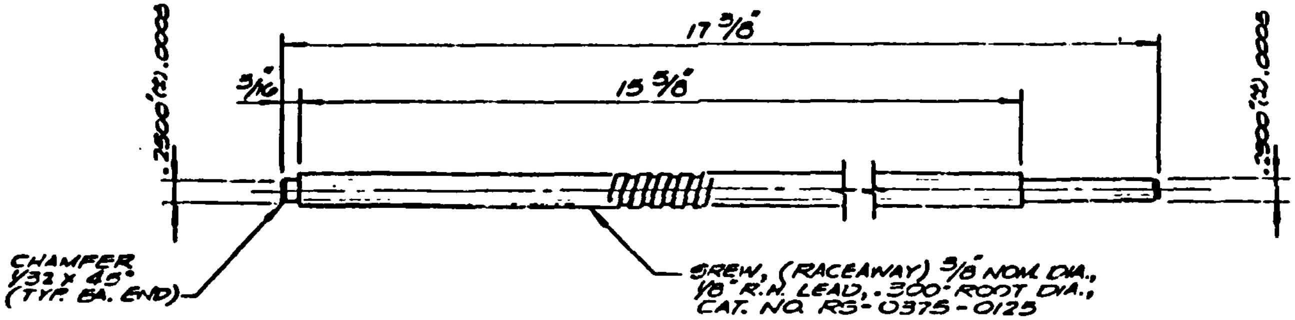


DETAIL ITEM (22) (C. STEEL)

SCALE: FULL

NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS Nº M0010 AND DWG 0010 & 0011.
2 ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".

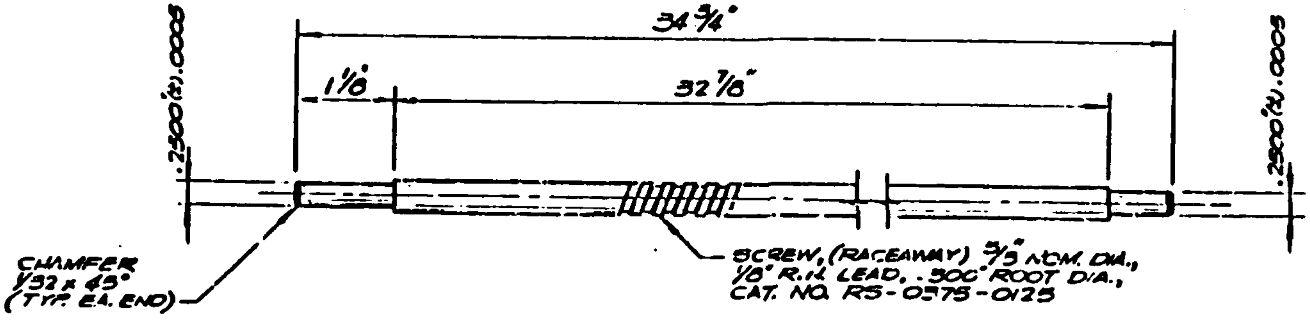


17 3/8"
15 5/8"
5/16"
.2500"(±).0005
.2500"(±).0005
CHAMFER 1/32 x 45° (TYP. EA. END)
SREW, (RACEAWAY) 3/8" NOM. DIA., 1/8" R.H. LEAD, .300" ROOT DIA., CAT. NO. RS-0375-0125

DETAIL ITEM (21) (C. STEEL)
SCALE: FULL

NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS Nº M0010 AND DWG 0010 & 0011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".



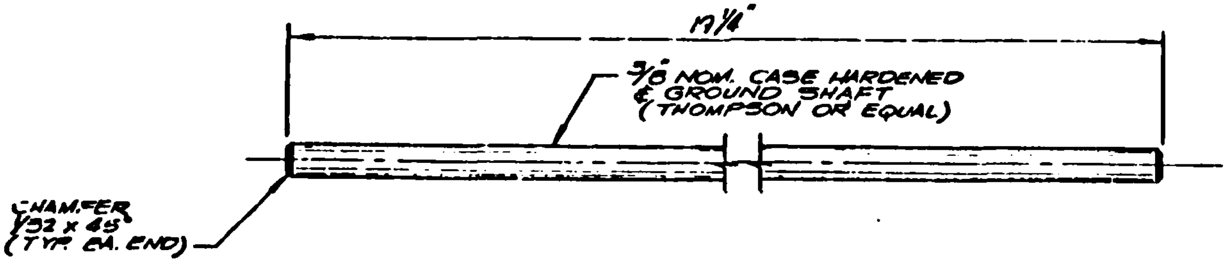
CHAMFER
1/32 x 45°
(TYP. EA. END)

SCREW, (RACEAWAY) 5/8" NOM. DIA.,
1/8" R.H. LEAD, .500" ROOT DIA.,
CAT. NO. RS-0575-0125

DETAIL ITEM (20) (C. STEEL)
SCALE: FULL

NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS Nº M0010 AND DWG. 0010 & 0011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".

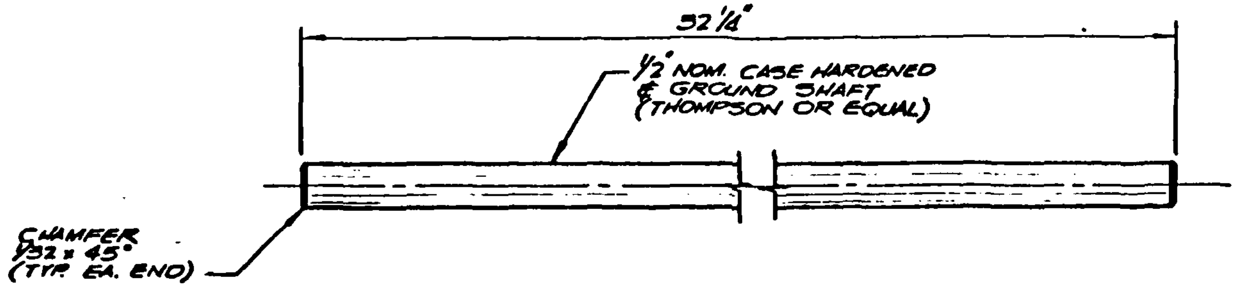

17 1/4"
3/8" NOM. CASE HARDENED & GROUND SHAFT (THOMPSON OR EQUAL)
CHAMFER 1/32 x 45° (TYP. EA. END)

DETAIL ITEM (19) (C. STEEL)

SCALE: FULL

NOTES

1. WORK THIS DWG. WITH BILL OF MATERIALS Nº M0010 AND DWG. 0010 & 0011.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".


32 1/4"
1/2" NOM. CASE HARDENED & GROUND SHAFT (THOMPSON OR EQUAL)
CHAMFER 1/32 x 45° (TYP. EA. END)

DETAIL ITEM (18) (C. STEEL)
SCALE: FULL

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No M0001	Sheet 4 of 8
Prepared by FORREST BLAIR	Date 7-10-81		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title TURRET PUNCH			

REVISIONS NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
29	0001 & 2	Bearing - Linear, 5/8" O.D. x	8	Mfg. Std.	
		7/8" Long, Cat. No. A-61014		Thompson	
30	0001	Bearing - Model No. 37KDD for	2	Mfg. Std.	
		1/4" Shaft		Fafnir	
31	0001	Bushing - 3/8" Nom. I.D. x	1	Mfg. Std.	
		9/16" Nom. O.D., Cat No. 56829		Boston Gear	
		P69-3			
32	0002	Bushing - 1/2" Nom. I.D. x	1	Mfg. Std.	
		3/4" Nom. O.D., Cat. No.		Boston Gear	
		35606 FB-812-12			
33	0002	Bushing - 1/2" Nom. I.D. x	1	Mfg. Std.	
		3/4" Nom. O.D., Cat. No.		Boston Gear	
		35596 FB-812-4			
34	0001	Coupling - 1/4" Nom. Bore,	2	Mfg. Std.	
		Model No. L050		Love Joy	

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BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No M0001	Sheet 5 of 8
Prepared by FORREST BLAIR	Date 7-10-81		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title TURRET PUNCH			

REVISIONS NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
35	0001	Bellows - Attach as required		As Required	
36	0001 & 2	Ball Nut - for 3/8" Nom. Screw,	2	Mfg. Std.	
		Cat. No. RN-0375-0125		Raceaway	
37	0002	Spring - Plunger, 1/2" O.D.,	1	Mfg. Std.	
		Cat. No. S-193, Stainless		Century	
		Compression			
38	0002	Spring- Punch, 3/8" O.D., Cat.	8	Mfg. Std.	
		No. 1785, Music Compression		Century	
39		Not Used			
40		Not Used			
41	0001 & 2	Cap Screw - Hex Socket,	5	C. Steel	
		1/4-20 UNC x 1/2" Long			
42	0002	Cap Screw - Hex Socket,	1	C. Steel	
		1/4-20 UNC x 1/2" Long			

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BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No	Drawing No M0001	Sheet 6 of 8
Prepared by FORREST BLAIR	Date 7-10-81		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title TURRET PUNCH			

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
4	0002	Cap Screw - Hex Socket, #10-24 UNC x 3/8" Long	4	C. Steel	
44	0001	Cap Screw - Hex Socket, #10-24 UNC x 3/4" Long	8	C. Steel	
45	0001	Cap Screw - Hex Socket, #12-24 UNC x 3/4" Long	4	C. Steel	
46	0001 & 2	Machine Screw - Hex Head, #12-24 UNC x 1" Long	4	C. Steel	
47	0002	Cap Screw - Hex Socket, #8-32 UNC x 3/8" Long	2	C. Steel	
48	0001	Cap Screw - Hex Socket, #8-32 UNC x 5/8" Long	4	C. Steel	
49	0002	Cap Screw - Hex Socket, #5-40 UNC x 3/8" Long	16	C. Steel	

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BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0001	Sheet 7 of 8
Prepared by FORREST BLAIR	Date 7-10-81		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title TURRET PUNCH			

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
50	0001 & 2	Machine Screw - Slotted Fillister Head, #5-40 UNC x 3/8" Long	2	C. Steel	
51	0002	Machine Screw - Slotted 100° Flat Head, #5-40 UNC x 1/4" Long	16	C. Steel	
52	0002	Machine Screw - Slotted Truss Head, #5-40 UNC x 1/4" Long	4	C. Steel	
53	0001	Set Screw - Hex Sock t, #5 x 1/8" Long	6	C. Steel	
54	0002	Set Screw - Hex Socket, #10 x 3/16" Long	2	C. Steel	
55	0002	Dowel Pin - 1/8"	2	C. Steel	
56	0001 & 2	Washer - Flat, 1/4"	2	C. Steel	
57	0001 & 2	Washer - Flat, #12	4	C. Steel	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0001	Sheet 8 of 8

Prepared by: FORREST BLAIR — Date: 7-10-31

Approved by: — Date:

Project Engineer: — Date:

Project Name: CAD-CAM

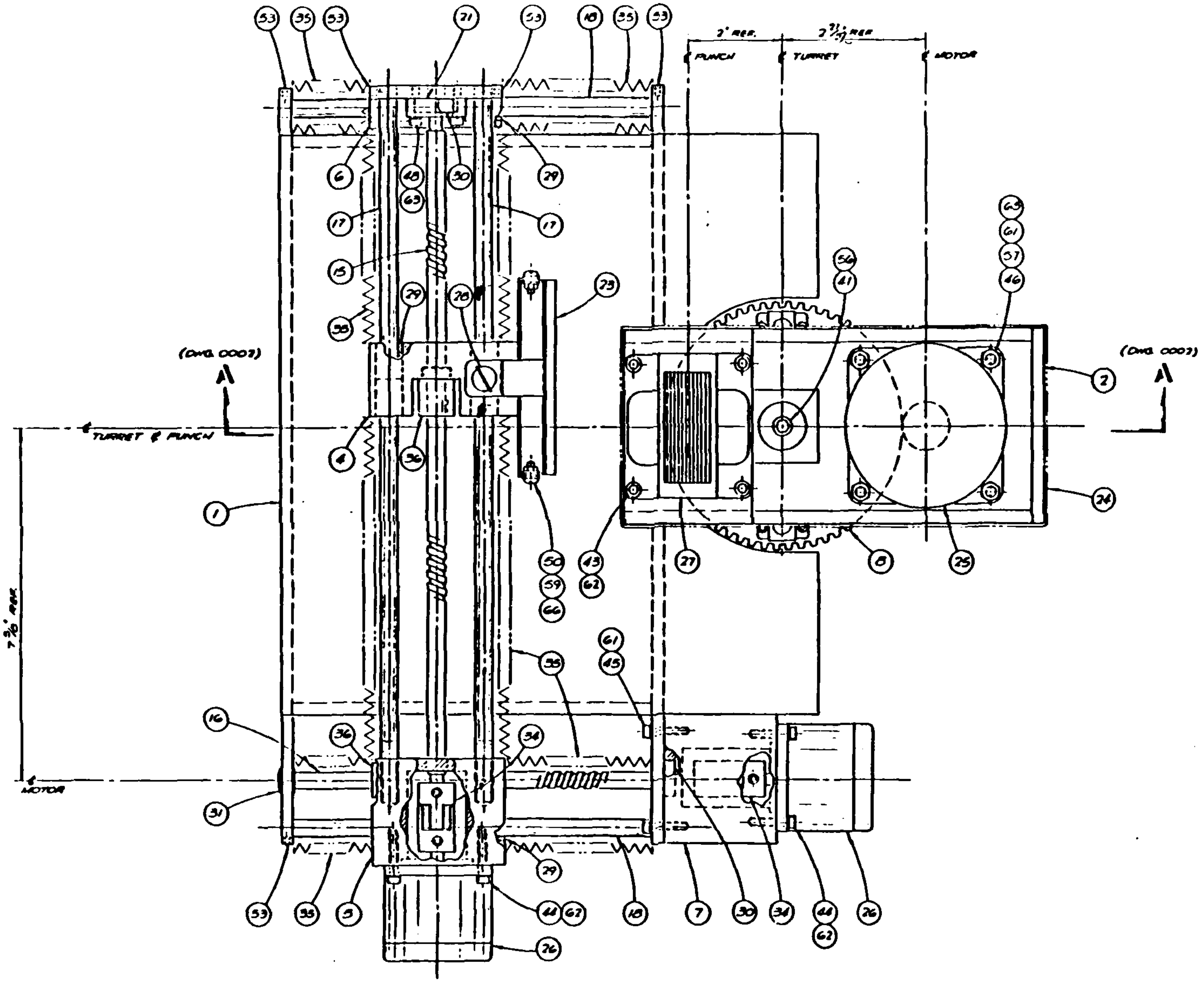
Drawing Title: TURRET PUNCH

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
58	0002	Washer - Flat, #8	2	C. Steel	
59	0001 & 2	Washer - Flat, #5	4	C. Steel	
60	0001 & 2	Washer - Lock, 1/4"	4	C. Steel	
61	0001 & 2	Washer - Lock, #12	8	C. Steel	
62	0001 & 2	Washer - Lock, #10	12	C. Steel	
63	0002	Washer - Lock, #8	6	C. Steel	
64	0002	Washer - Lock, #5	16	C. Steel	
65	0001 & 2	Nut - Hex Head, #12	4	C. Steel	
66	0001 & 2	Nut - Hex Head, #5	2	C. Steel	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.



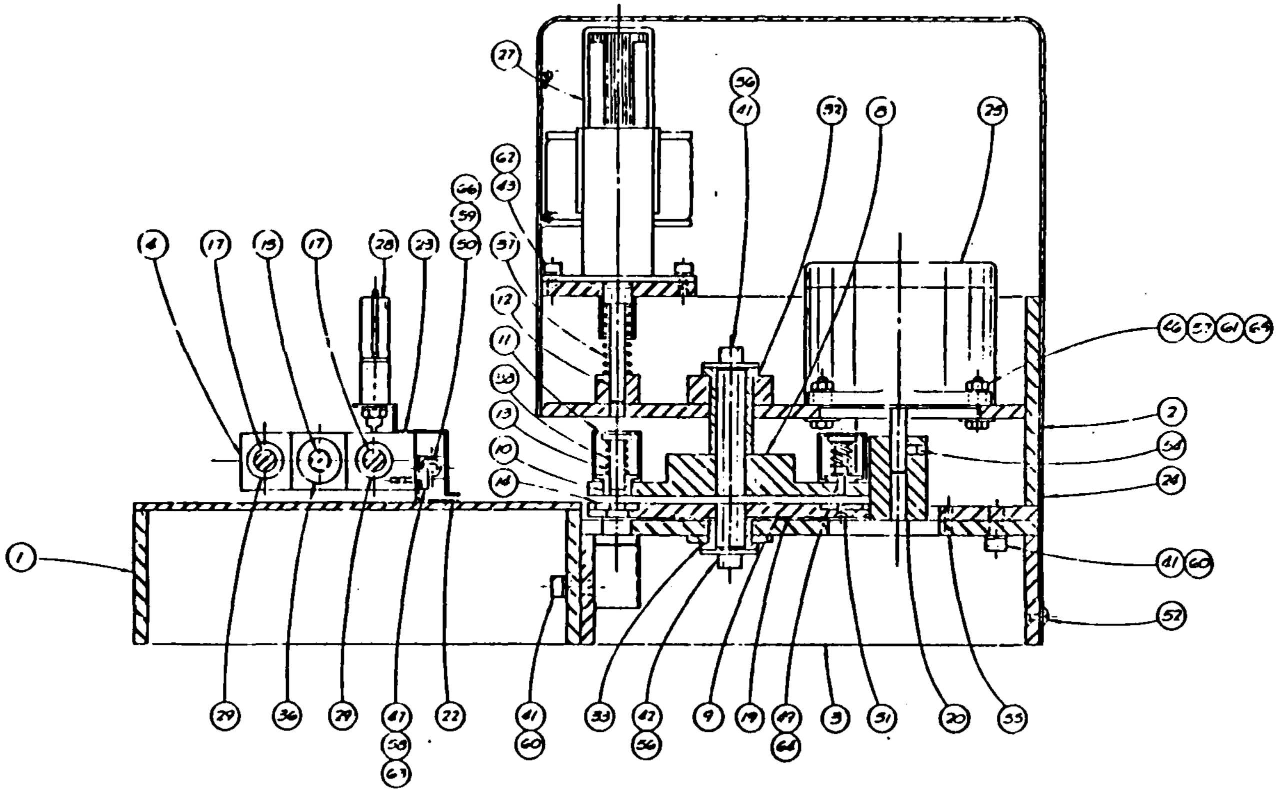
PLAN VIEW

FULL SCALE

NOTES

1 ALL ITEMS MARKED THUS ○ ARE FOUND ON BILL OF MATERIALS Nº M0001.

JULY 10, 1981 CAD-CAM DEPT	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	TURRET PUNCH	ASSEMBLY-PLAN		FORREST BLAIR

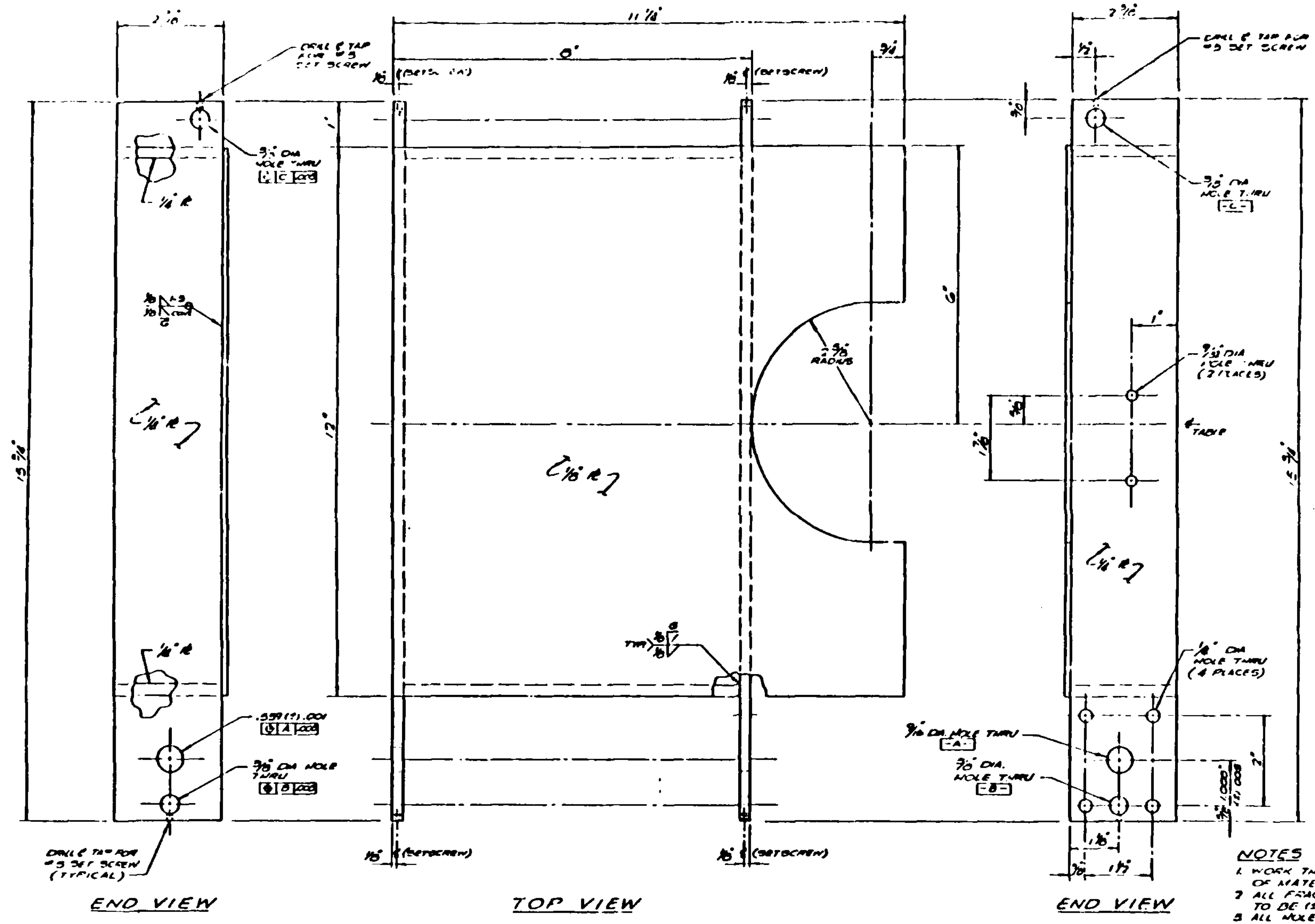


SECTION A-A (DWG. 0001)

FULL SCALE

NOTES
1. ALL ITEMS MARKED THUS ○ ARE FOUND ON BILL OF MATERIALS Nº MOC01.

JULY 10, 1981	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	TURRET PUNCH	ASSEMBLY - SECTION	[illegible]	[illegible]

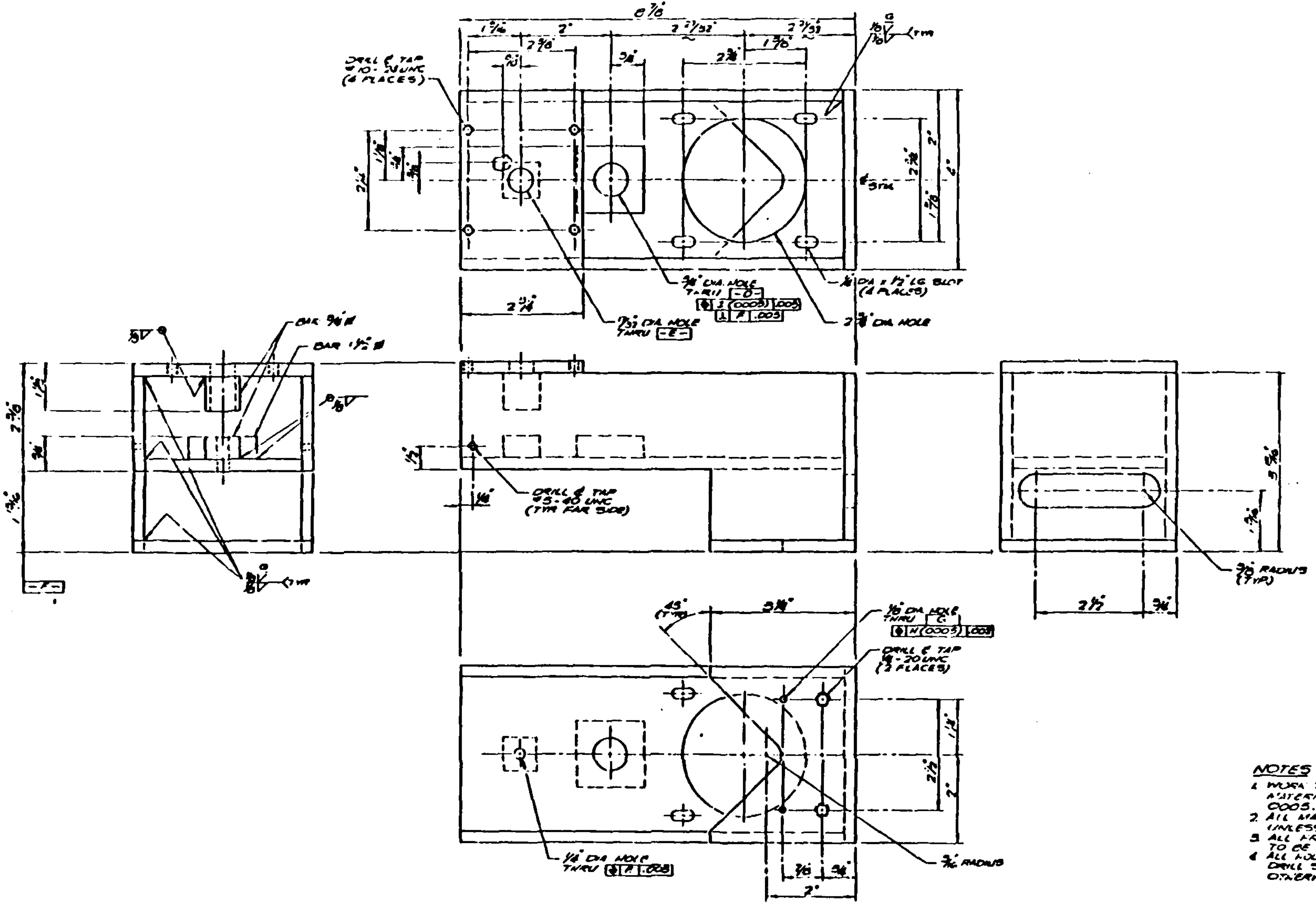


DETAIL ITEM (1) (C. STEEL)

FULL SCALE

NOTES
1. WORK THIS DWG WITH BILL OF MATERIALS M0001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1⁄64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

JULY 10, 1981 CAD - CAM DEPT.	BRIGHAM YOUNG UNIVERSITY	TURRET PUNCH	DETAIL ITEM 1	FORREST BLAIR	0003

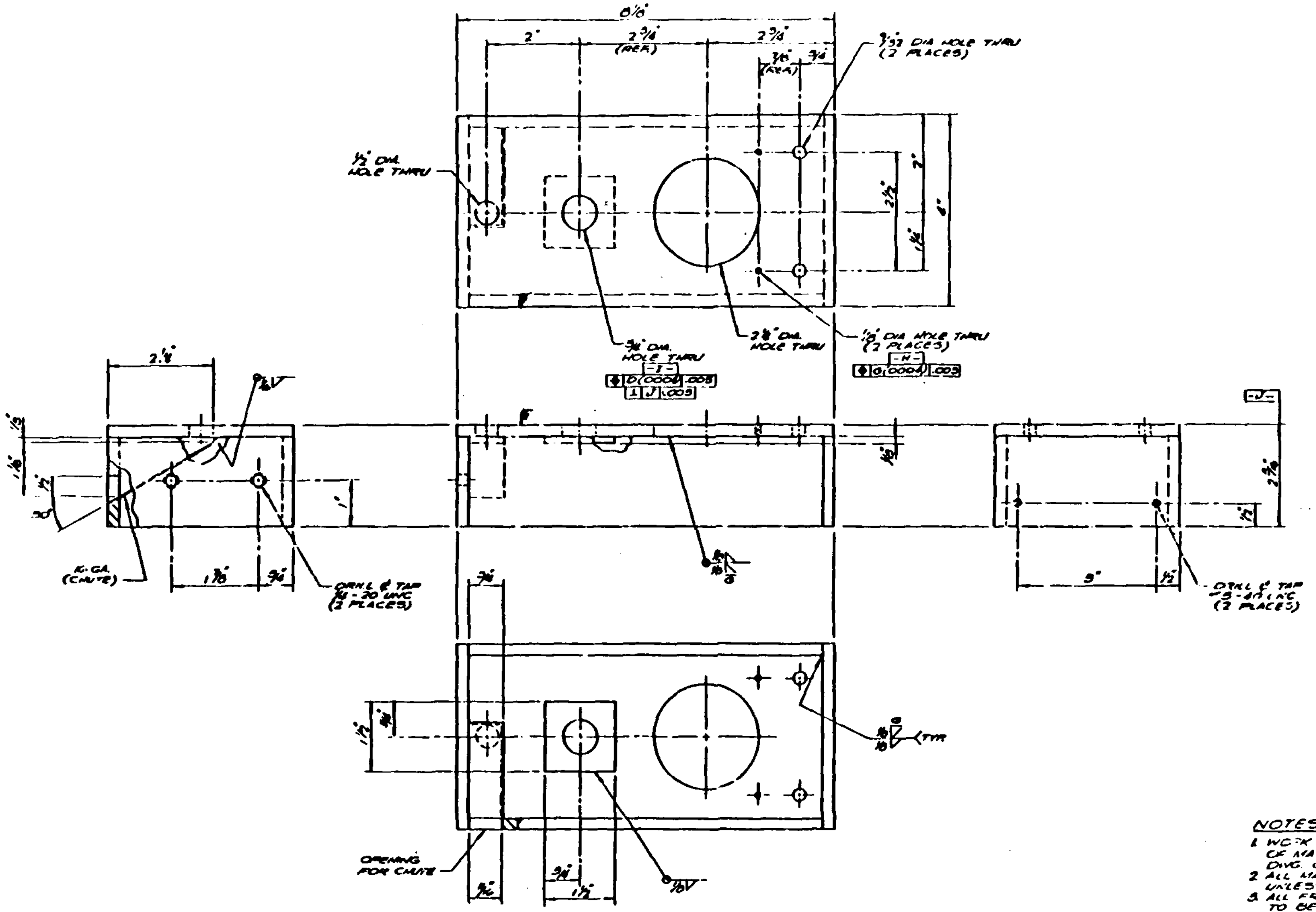


NOTES
1. WORK THIS DWG WITH BILL OF MATERIALS M0001 AND DWG. 0005.
2. ALL MATERIAL SHALL BE 1/3"R UNLESS SHOWN OTHERWISE.
3. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
4. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

DETAIL ITEM (2) (C. STEEL)

FULL SCALE

JULY 10, 1981 CAD - CAM	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	TURRET PUNCH	DETAIL ITEM 2		FORREST BLAIR	0004



DETAIL ITEM (3) (C. STEEL)

FULL SCALE

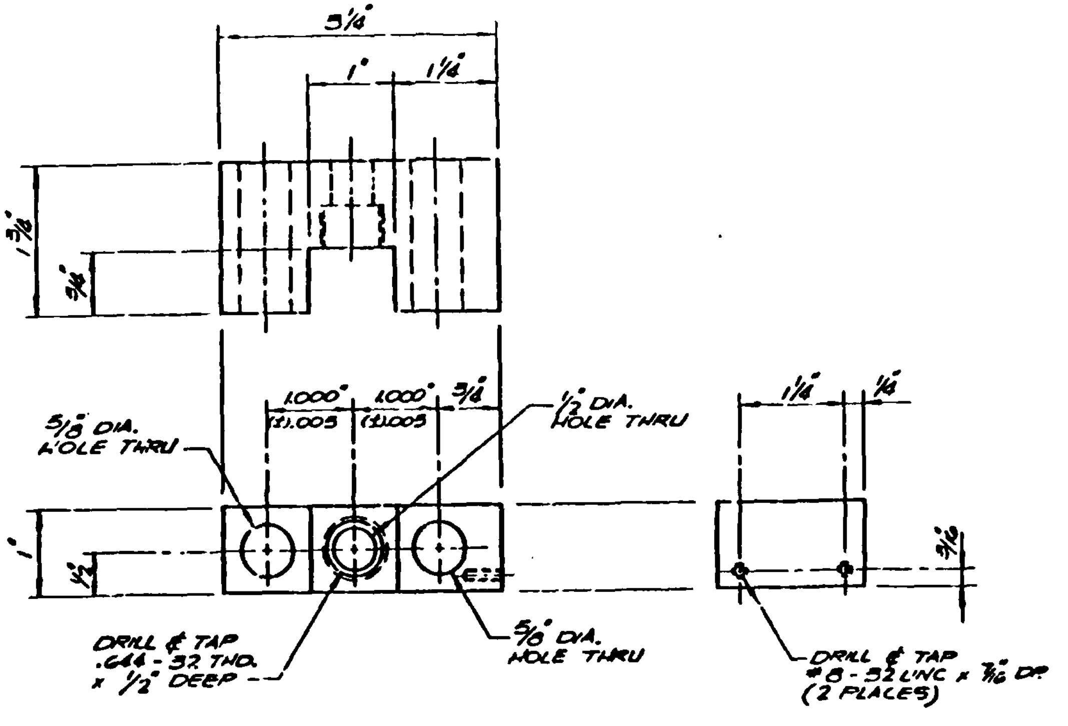
NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS M0001 AND DWG. 0004.
2. ALL MATERIAL SHALL BE 1/8" R UNLESS SHOWN OTHERWISE.
3. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
4. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

JULY 10, 1981 CAD - CAM DEPT.	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	TURRET PUNCH	DETAIL ITEM 3		FORREST BLAIR	0005

NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS MC001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

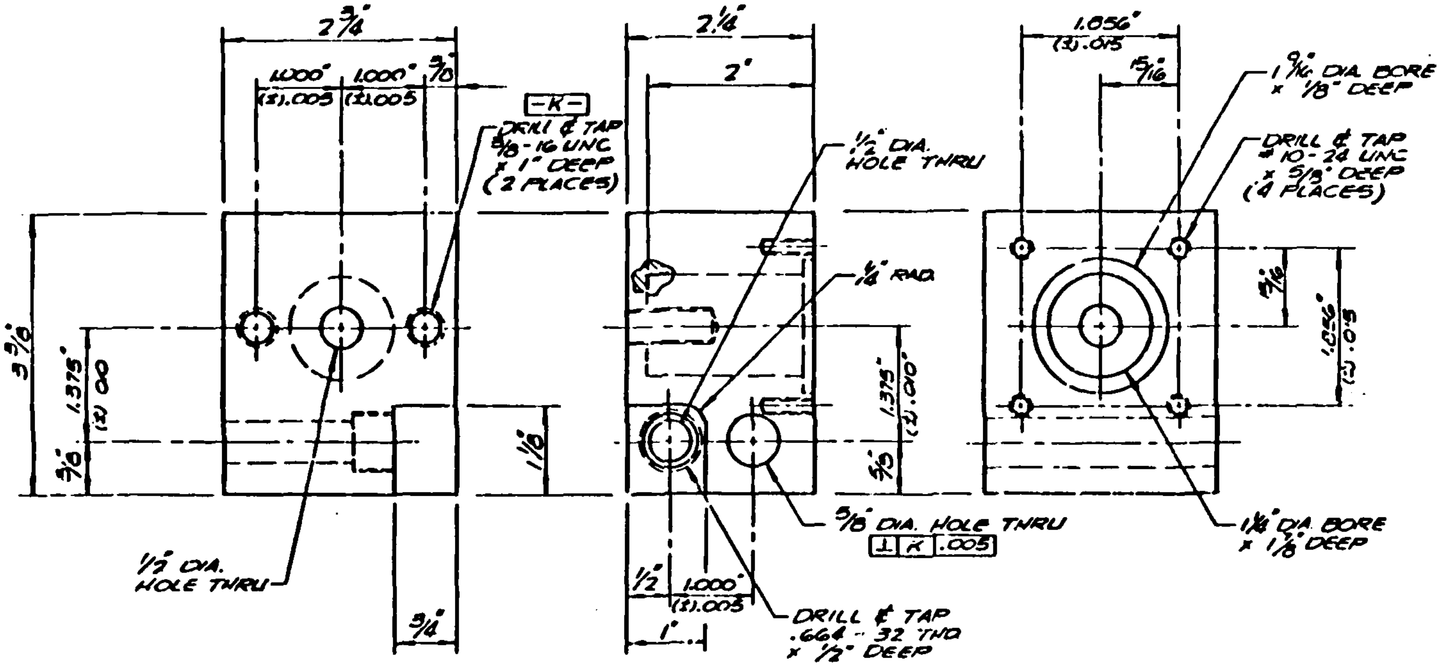


DETAIL ITEM (4) (ALUMINUM)

FULL SCALE

NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS MC001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64" UNLESS SHOWN OTHERWISE.
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

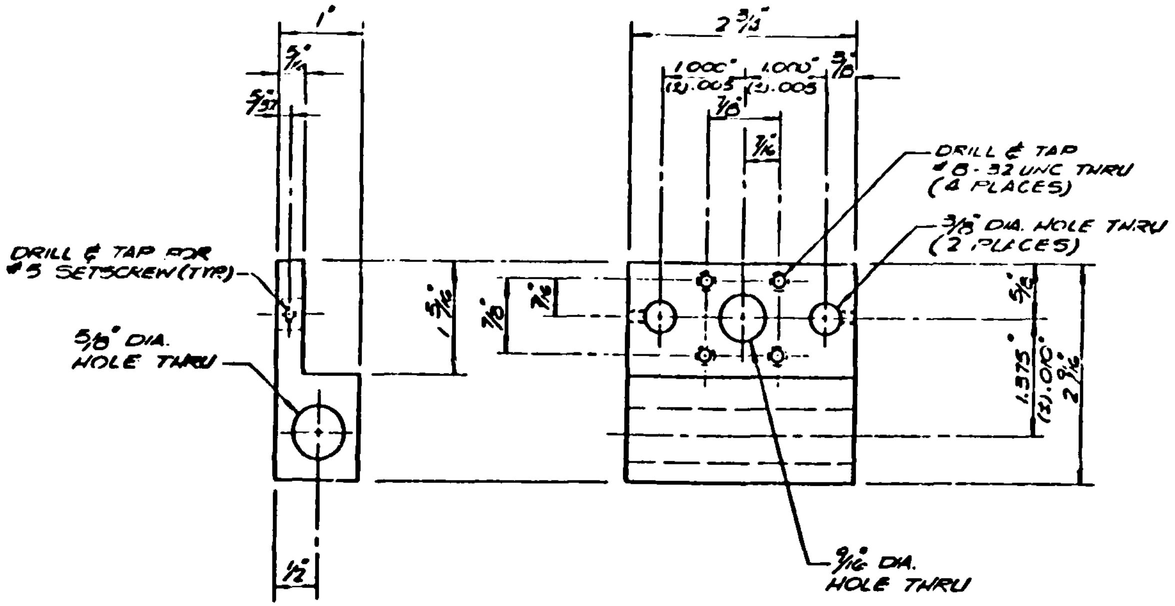


DETAIL ITEM (5) (ALUMINUM)

FULL SCALE

NOTES

1. WORK THIS DWG. WITH BILL OF MATERIALS MC001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64" UNLESS SHOWN OTHERWISE.
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

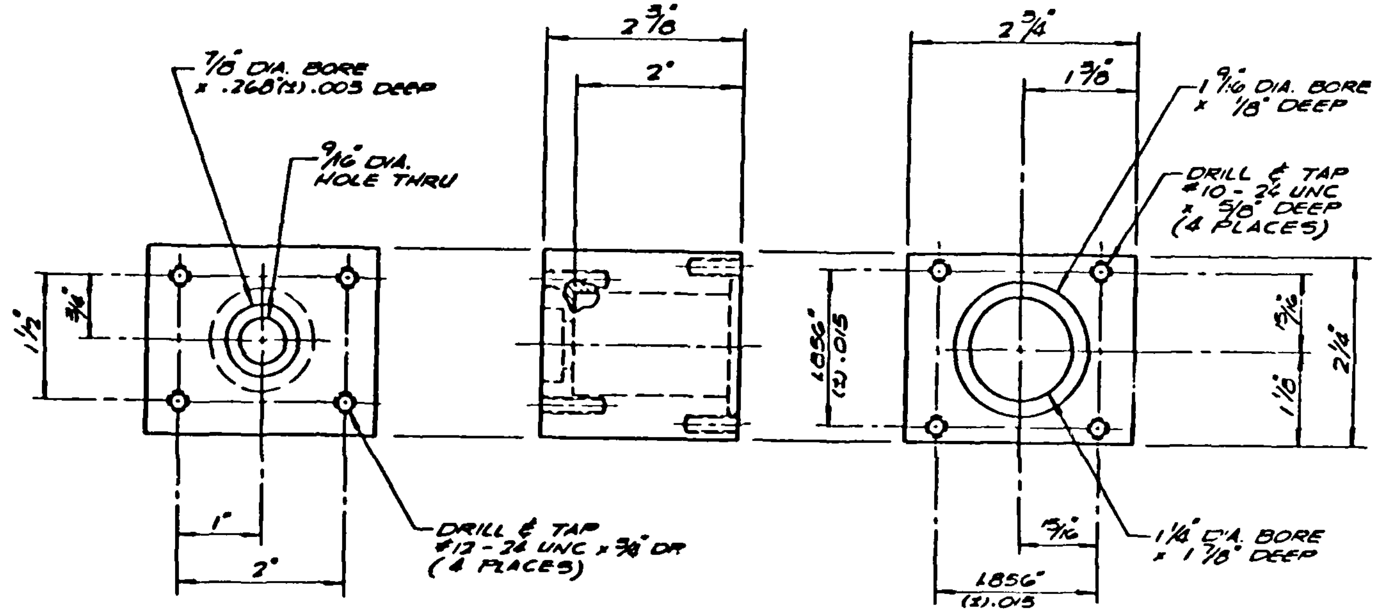


DETAIL ITEM (6) (ALUMINUM)

FULL SCALE

NOTES

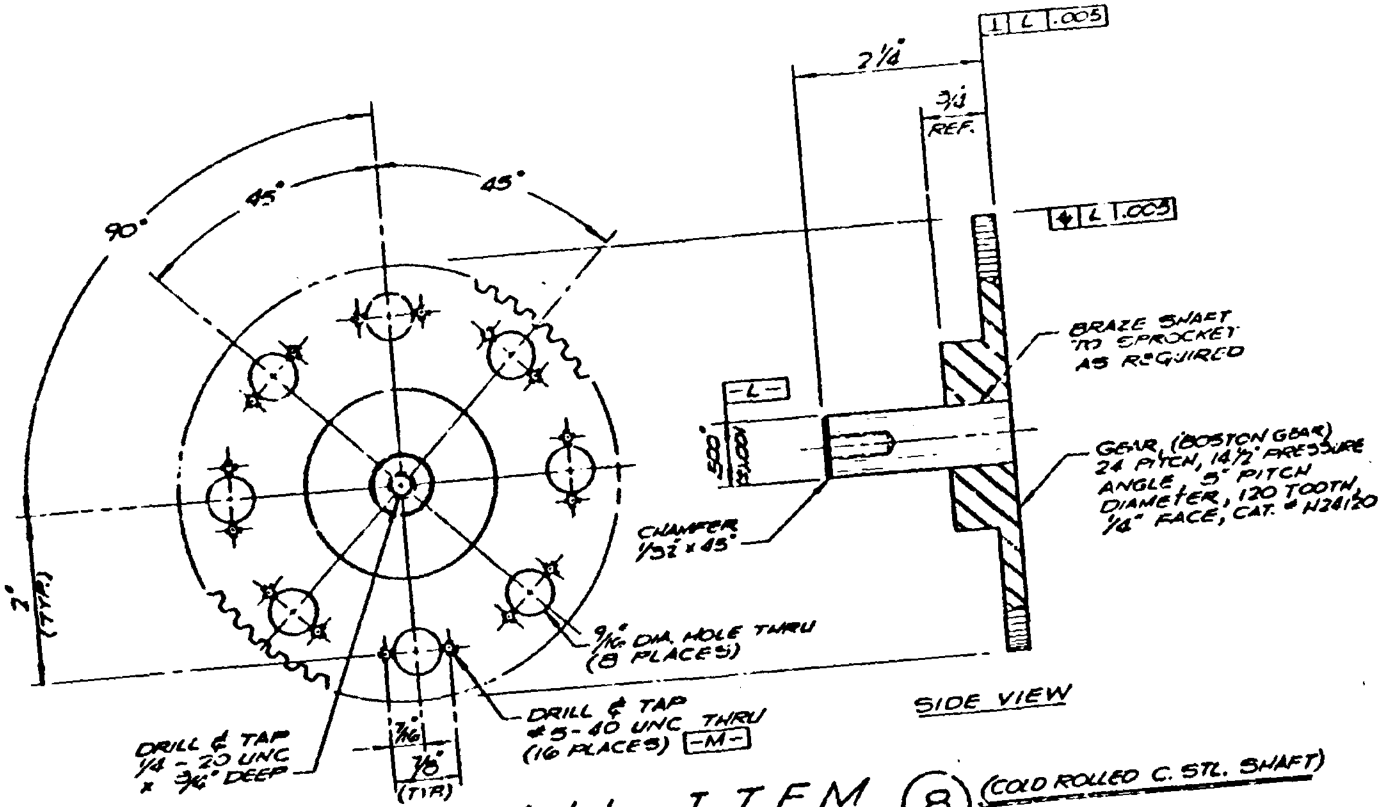
1. WORK THIS DWG WITH BILL OF MATERIALS MC001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64" UNLESS SHOWN OTHERWISE.
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.


7/8" DIA. BORE x .268(±).005 DEEP
9/16" DIA. HOLE THRU
1 1/2"
3/4"
1"
2"
DRILL & TAP #12 - 24 UNC x 3/8" DP (4 PLACES)
2 3/8"
2"
1.856" (±).015
2 3/4"
1 3/8"
1 9/16" DIA. BORE x 1/8" DEEP
DRILL & TAP #10 - 24 UNC x 5/8" DEEP (4 PLACES)
15/16"
1 1/8"
2 1/4"
1 1/4" DIA. BORE x 1 7/8" DEEP
15/16"
1.856" (±).015

DETAIL ITEM 7 (ALUMINUM)

FULL SCALE

NOTES
1. WORK THIS DWG WITH BILL OF MATERIALS M0001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL ANGLES TO BE (±) 1/2° UNLESS SHOWN OTHERWISE.
4. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.



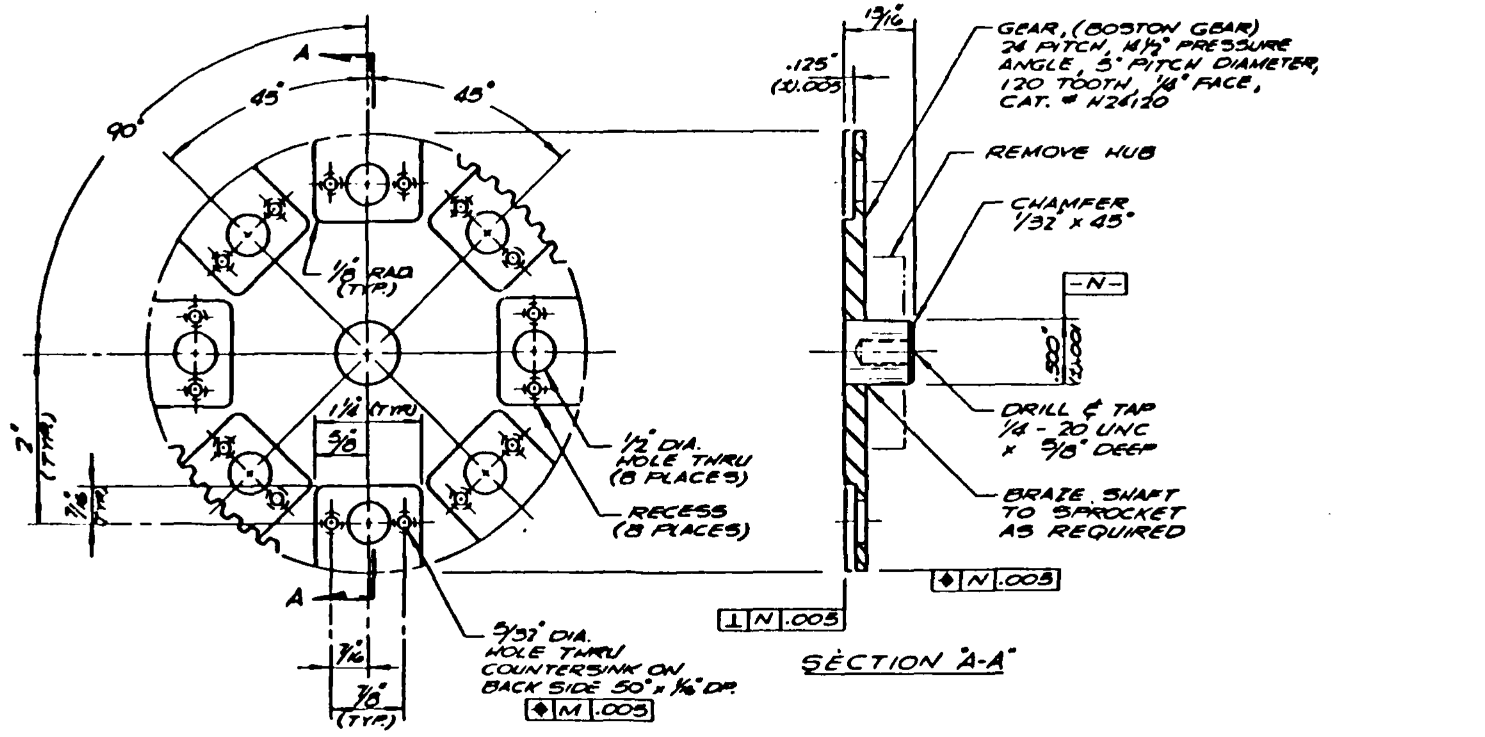
90°
45°
45°
2" (TYP.)
9/16" DIA. HOLE THRU (8 PLACES)
DRILL & TAP #5-40 UNC THRU (16 PLACES) -M-
DRILL & TAP 1/4-20 UNC x 3/16" DEEP
7/16"
7/8" (TYP.)
2 1/4"
3/4 REF.
⊥ L .005
⌖ L .005
-L-
.500 / .5001
CHAMFER 1/32 x 45°
BRAZE SHAFT TO SPROCKET AS REQUIRED
GEAR (BOSTON GEAR) 24 PITCH, 14 1/2° PRESSURE ANGLE, 5" PITCH DIAMETER, 120 TOOTH, 1/4" FACE, CAT. # H24120
SIDE VIEW

DETAIL ITEM (8) (COLD ROLLED C. STL. SHAFT)

FULL SCALE

NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS MOC01.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL ANGLES TO BE (±) 1/2° UNLESS SHOWN OTHERWISE.
4. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.


A
90°
45°
45°
1/8" RAD (TYP.)
1 1/4 (TYP.)
3/8"
2" (TYP.)
7/16"
1/2" DIA. HOLE THRU (8 PLACES)
RECESS (8 PLACES)
5/32" DIA. HOLE THRU COUNTERSINK ON BACK SIDE 50° x 1/16" DP.
◆ M .005
7/16
7/8" (TYP.)
A
13/16"
.125" (±.005)
GEAR, (BOSTON GEAR) 24 PITCH, 14 1/2° PRESSURE ANGLE, 5" PITCH DIAMETER, 120 TOOTH, 1/4" FACE, CAT. # H24120
REMOVE HUB
CHAMFER 1/32" x 45°
-N-
.500" (±.001)
DRILL & TAP 1/4 - 20 UNC x 5/8" DEEP
BRAZE SHAFT TO SPROCKET AS REQUIRED
◆ N .005
⊥ N .005
SECTION "A-A"

DETAIL ITEM (9) (COLD ROLLED C. STL. SHAFT)

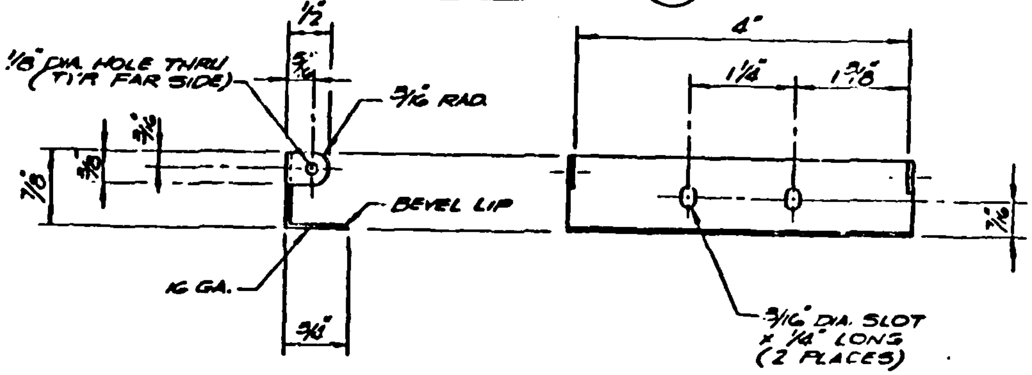
FULL SCALE

NOTES

1. WORK THIS DWG. WITH BILL OF MATERIALS M[illegible]001.
2. ALL FRACTION DIMENSIONS TO BE (±) 1/32" UNLESS SHOWN OTHERWISE.
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

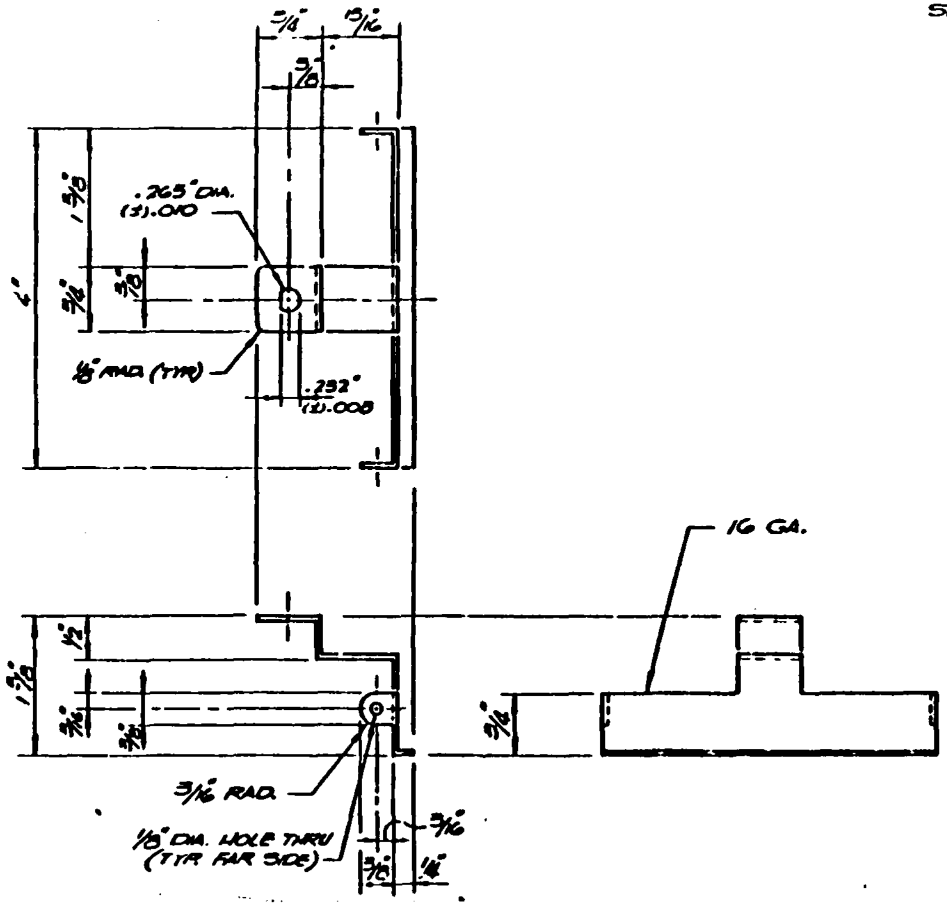
DETAIL ITEM (23) (C. STEEL)

FULL SCALE


1/2"
5/16"
1/8" DIA. HOLE THRU (T'I'R FAR SIDE)
3/16" RAD.
3/16"
3/8
7/8"
BEVEL LIP
16 GA.
3/8"
4"
1 1/4"
1 3/8"
7/16
3/16" DIA. SLOT x 1/4" LONG (2 PLACES)

NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS MC001.
2. ALL FRACTION DIMENSIONS TO BE (±) 1/32" UNLESS SHOWN OTHERWISE.
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

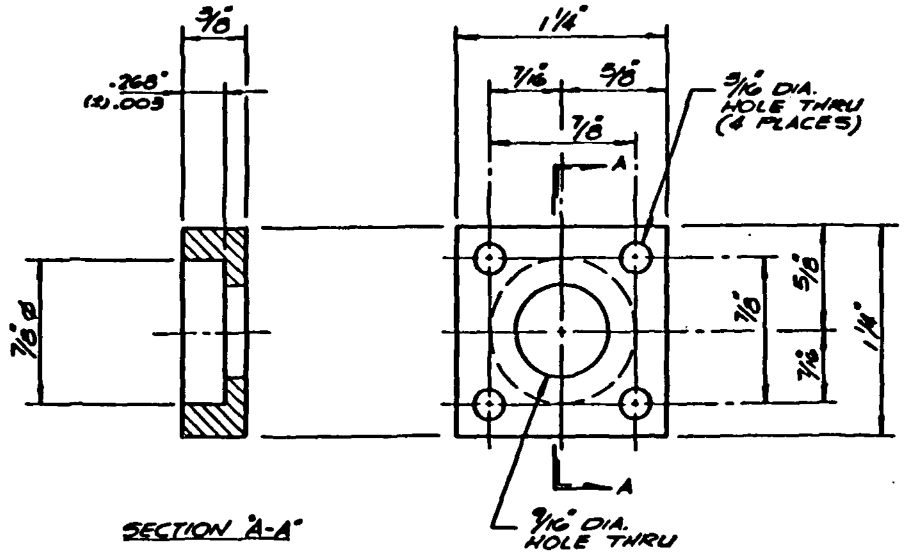


DETAIL ITEM (22) (C. STEEL)

FULL SCALE

NOTES

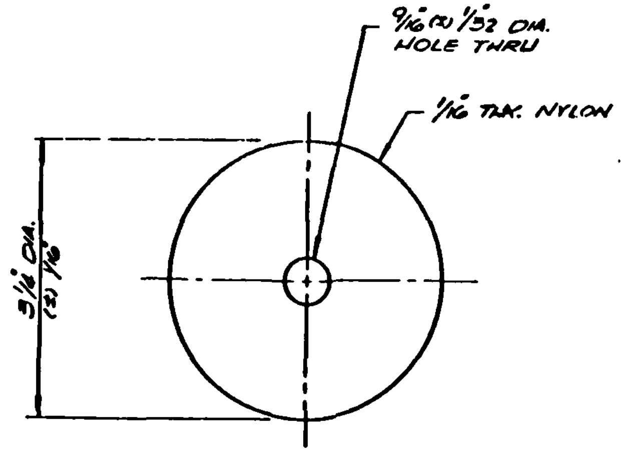
1. WORK THIS DWG WITH BILL OF MATERIALS M0001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64" UNLESS SHOWN OTHERWISE.
3. ALL HOLE SIZES SHALL EE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.



DETAIL ITEM (21) (ALUMINUM)
FULL SCALE

NOTES

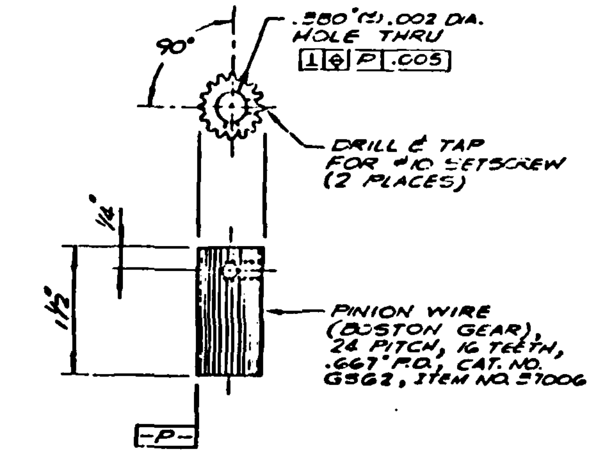
1. WORK THIS DWG WITH BILL OF MATERIALS MC001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64" UNLESS SHOWN OTHERWISE.
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.



DETAIL ITEM (19) (NYLON)
FULL SCALE

NOTES

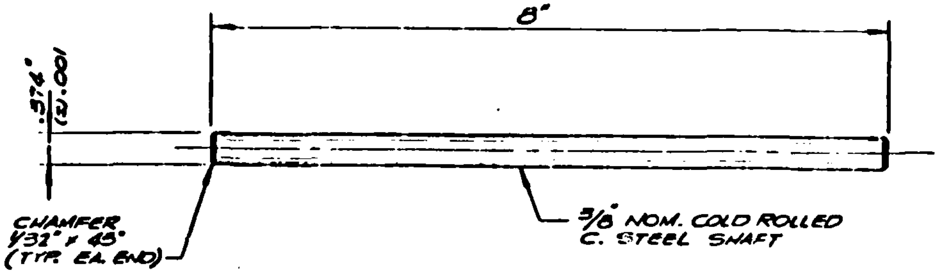
1. WORK THIS DWG WITH BILL OF MATERIALS MC001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64" UNLESS SHOWN OTHERWISE.
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.



DETAIL ITEM (20)

FULL SCALE

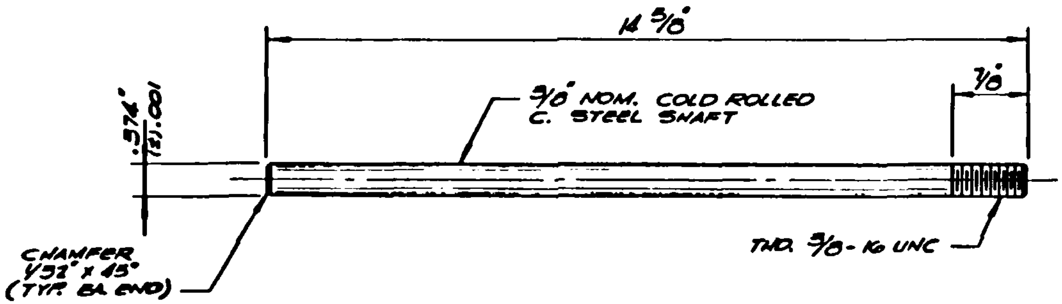
NOTES
1. WORK THIS DWG WITH BILL OF MATERIALS MC001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64" UNLESS SHOWN OTHERWISE.
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.



DETAIL ITEM (18) (C. STEEL)
FULL SCALE

NOTES

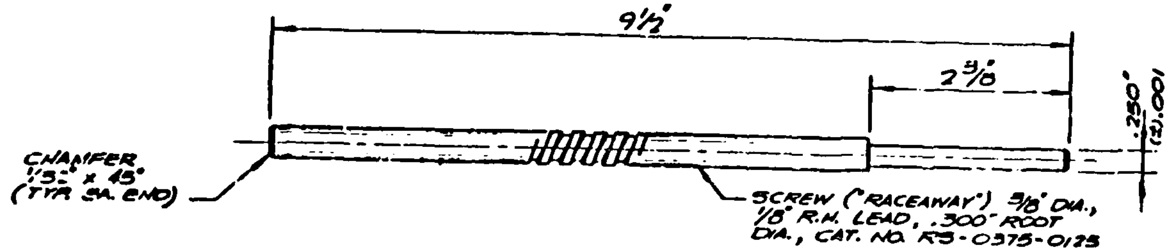
1. WORK THIS DWG WITH BILL OF MATERIALS MC001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64" UNLESS SHOWN OTHERWISE.
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.


14 5/8"
7/8"
5/8" NOM. COLD ROLLED C. STEEL SHAFT
.374" (±).001
THD. 5/8-16 UNC
CHAMFER 1/32" x 45° (TYP. EA. END)

DETAIL ITEM (17) (C. STEEL)
FULL SCALE

NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS MC001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64" UNLESS SHOWN OTHERWISE.
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

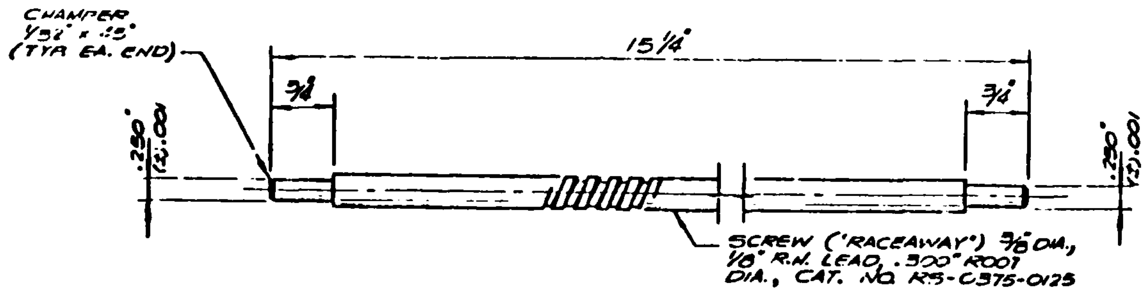

9½"
2⅝"
.250"
(±).001
CHAMFER
1/32" x 45°
(TYP EA. END)
SCREW ("RACEWAY") 3/8" DIA., 1/8" R.H. LEAD, .300" ROOT DIA., CAT. NO. RS-0375-0125

DETAIL ITEM (16)

FULL SCALE

NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS MC001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64" UNLESS SHOWN OTHERWISE.
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

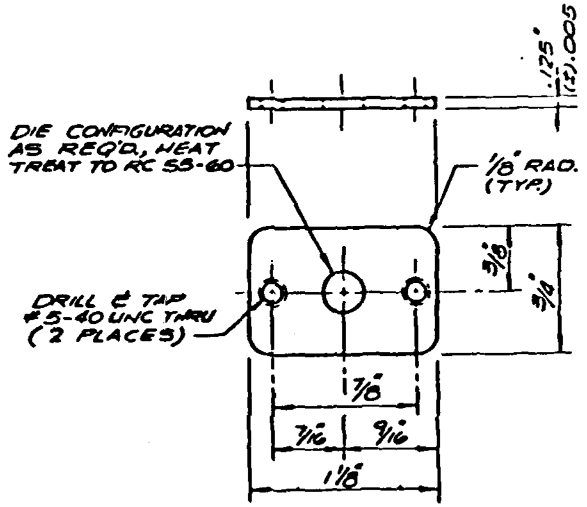

CHAMFER
1/32" × 45°
(TYP. EA. END)
15 1/4"
3/4"
3/4"
.250"
(±).001
.250"
(±).001
SCREW ('RACEAWAY') 3/8" DIA.,
1/8" R.H. LEAD, .300" ROOT
DIA., CAT. NO. RS-C375-0125

DETAIL ITEM (15)

FULL SCALE

NOTES

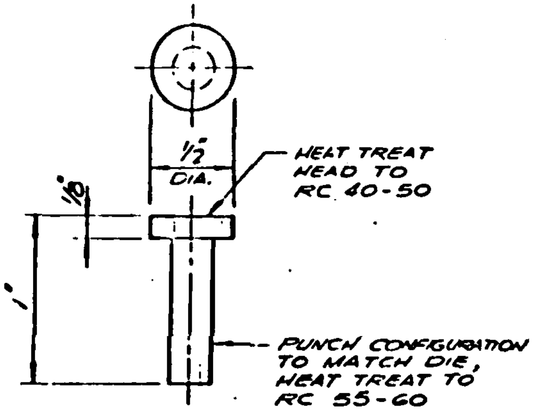
1. WORK THIS DWG WITH BILL OF MATERIALS MOCOI.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL ANGLES TO BE (±) 1/2° UNLESS SHOWN OTHERWISE.
4. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.



DETAIL ITEM (14) (C. STL.)
SCALE: 2"=1"

NOTES

1. WORK THIS DWG. WITH BILL OF MATERIALS MCC01.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL ANGLES TO BE (±) 1/2° UNLESS SHOWN OTHERWISE.
4. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

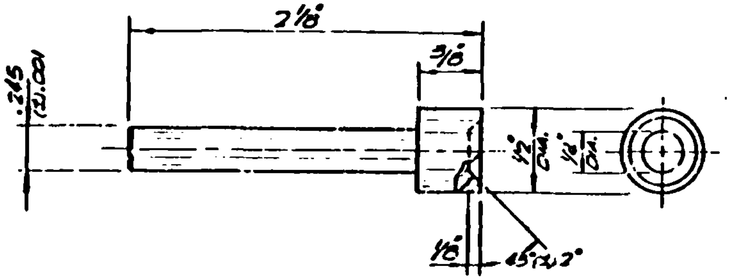

1/2"
DIA.
HEAT TREAT HEAD TO RC 40-50
1/10"
1"
PUNCH CONFIGURATION TO MATCH DIE, HEAT TREAT TO RC 55-60

DETAIL ITEM 13 (C. STL.)

SCALE: 2"=1"

NOTES

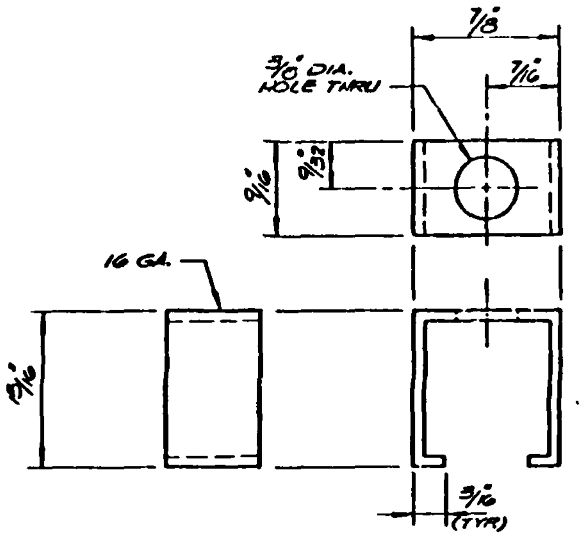
1. WORK THIS DWG WITH BILL OF MATERIALS NO. 01.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/32".
3. ALL ANGLES TO BE (±) 1/2° UNLESS SHOWN OTHERWISE.
4. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.



DETAIL ITEM (12) (C. STL.)
SCALE: 2"=1"

NOTES

1. WORK THIS DWG. WITH BILL OF MATERIALS MC001.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL ANGLES TO BE (±) 1/2° UNLESS SHOWN OTHERWISE.
4. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

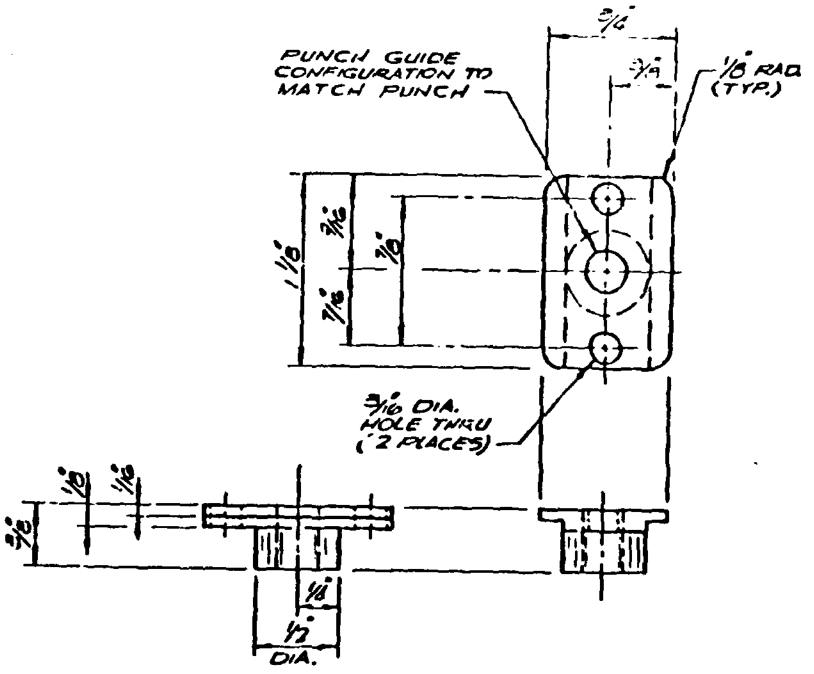


DETAIL ITEM (11) (C. STL.)

SCALE: 2"=1"

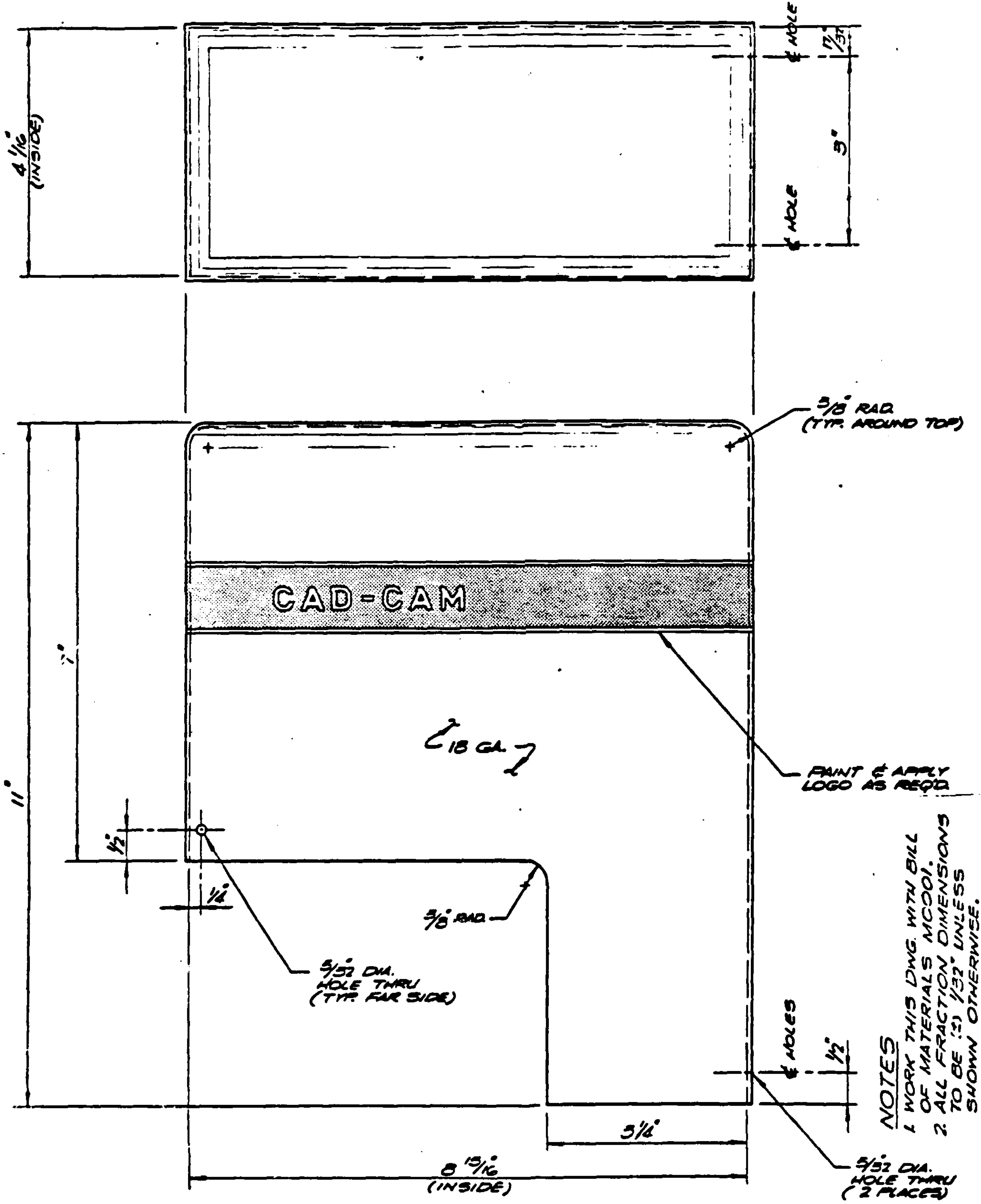
NOTES

1. WORK THIS DWG. WITH BILL OF MATERIALS MOC01.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL ANGLES TO BE (±) 1/2° UNLESS SHOWN OTHERWISE.
4. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.


PUNCH GUIDE CONFIGURATION TO MATCH PUNCH
3/4"
3/8"
1/8" RAD (TYP.)
1 1/8"
7/16"
7/16"
7/8"
3/16" DIA. HOLE THRU (2 PLACES)
1/8"
1/16"
3/8"
1/8"
1/2"
DIA.

DETAIL ITEM (10) (C. STL.)

SCALE: 2"=1"



NOTES

1. WORK THIS DWG. WITH BILL OF MATERIALS MC001.
2. ALL FRACTION DIMENSIONS TO BE (±) 1/32" UNLESS SHOWN OTHERWISE.
3. ALL HOLE SIZES SHALL BE ACTUAL DRILL SIZE UNLESS SHOWN OTHERWISE.

DETAIL ITEM (24) (C. STEEL OR EQUAL)

FULL SCALE

APPENDIX C

Detailed Design for a Miniature Polar-coordinate Milling Machine

BRIGHAM YOUNG UNIVERSITY

CAD-CAM DEPT.

BILL OF MATERIALS

PROJECT POLAR MILL (M0039)

DRAWING NO.	DESCRIPTION
0039	ASSEMBLY
0040	DETAIL ITEM 1 & 2
0041	DETAIL ITEMS 3, 4, & 5
0042	DETAIL ITEMS 6, 7, 8, 9, & 10
0043	DETAIL ITEMS 11, 12, 13, 14, 15, 16, & 17
0044	DETAIL ITEMS 18, 19, 20, 21, 22, 23, 24, 25, 26, & 27

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0039	Sheet 1 of
Prepared by FORREST BLAIR	Date 11-10-92		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title POLAR MILL			

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
	0039	Polar Mill Assembly	1 *		
1	0040	Base Frame	1	C. Steel	
2	0040	Base Cover	1	C. Steel	
3	0041	Arch Frame	1	C. Steel	
4	0041	Arch Rail	6	C. Steel	
5	0041	Arch Track Clamp	6	Aluminum	
6	0042	Arch Support	1	C. Steel	
7	0042	Cable Support Shaft	1	C. Steel	
8	0042	Cable Attachment	1	Aluminum	
9	0042	Turret Support	1	C. Steel	
10	0042	Turret Support Shaft	1	C. Steel	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0039	Sheet 2 of
Prepared by FORREST BLAIR	Date 11-10-92		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title POLAR MILL			

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
11	0043	Track Drive Plate	1	C. Steel	
12	0043	Inner Drive Screw	1	See Detail	
13	0043	Outer Drive Screw	1	See Detail	
14	0043	Turret Plate	1	Aluminum	
15	0043	Turret Chain Clamp	1	Aluminum	
16	0043	Inner Slide	1	Aluminum	
17	0043	Outer Slide	1	Aluminum	
18	0044	Cutter Support	1	Aluminum	
19	0044	Cutter Support Shaft	1	C. Steel	
20	0044	Cutter Drive Support	1	Aluminum	
21	0044	Slide Track	4	See Detail	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0039	Sheet 3 of
Prepared by FORREST BLAIR	Date 11-10-92		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title POLAR MILL			

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
22	0044	Slide Top Cap	1	Aluminum	
23	0044	Slide Bottom Cap	1	Aluminum	
24	0044	Turret Roller Support	9	Aluminum	
25	0044	Upper Ball Nut Support	1	Aluminum	
26	0044	Upper Shaft Support	1	Aluminum	
27	0044	Lower Ball Nut Support	1	Aluminum	
28	0039	Motor - DC Stepping, Slo-syn. #M061-FC02	4	Mfg. Std. Superior Electric	
29	0039	Motor - 1/15 H.P., 3U1-005K	1	Mfg. Std. Stock Drive Products	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0039	Sheet 4 of
Prepared by FORREST BLAIR	Date 11-10-82		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title POLAR MILL			

REVISIONS NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
30	0039	Cable Reel - "Negator" ML 1851	2	Mfg. Std.	
				Stock Drive	
				Products	
31	0039	Chain - 24 Pitch, 24GCF-919-E,	1	Mfg. Std.	
		919 Pitches, 107.21" circ.		W. Berg	
32	0039	Chain - 16 Pitch, 16GCF-10 FT.,	1	Mfg. Std.	
		563 Pitches		W. Berg	
33	0039	Sprocket - .15709 Pitch,	1	Mfg. Std.	
		3/4" P.D., 3MP26S-15		W. Berg	
34	0039	Sprocket - 1.200" P.D., 24 Teeth,	2	Mfg. Std.	
		.15703 Pitch, 3MP26S-24		W. Berg	
35	0039	Chain - .15703 Pitch, 40 Pitches,	1	Mfg. Std.	
		6.283" circ., 3CCF-40-E		W. Berg	
36	0039	Chain - .15709" Pitch, 90 Pitches	1	Mfg. Std.	
		14.137" circ., 3CCF-90-E		W. Berg	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0039	Sheet 5 of
Prepared by FORREST BLAIR	Date 11-10-32		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title POLAR MILL			

REVISIONS NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
37	0039	Bearing - Radial Thrust, .9843"	2	Mfg. Std.	
		Bore, 7205W		Fafnir	
38	0039	Bushing - ½" I.D., 11/16" O.D.,	1	Mfg. Std.	
		5/8" Long, 34738 B811-5		Boston Gear	
39	0039	Washer - Thrust, ½" Bore,	4	Mfg. Std.	
		B5-3-SS		W. Berg	
40	0039	Bushing - 5/16" I.D., ½" O.D.,	4	Mfg. Std.	
		1½" Long, Plain Cylindrical,		Boston Gear	
		34630 B59-12			
41	0039	Sprocket - 3" P.D., .15709" Pitch,	1	Mfg. Std.	
		3MF17S-60 (Drill 4 holes to match		W. Berg	
		item 18)			
42	0039	Washer - Thrust, ½" Bore, B5-6-SS	2	Mfg. Std.	
				W. Berg	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0039	Sheet 6 of
Prepared by FORREST BLAIR	Date 11-10-82		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title POLAR MILL			

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
43	0039	Sprocket - 24 Pitch, 2¼" P.D., 24B4-60	1	Mfg. Std. W. Berg	
44	0039	Sprocket - 16 Pitch, 1" P.D., 16B4-16	1	Mfg. Std. W. Berg	
45	0039	Speed Reducer - 2:1 Ratio, 2Z22-2RR0208	1	Mfg. Std. W. Berg	
46	0039	Coupling - Wafer Spring, ¼" Bore, C020-14	2	Mfg. Std. W. Berg	
47	0039	Bearing - 3/8" Nom. Bore, 7/8" O.D. 7Y55-P8737	8	Mfg. Std. W. Berg	
48	0039	Guide Wheel - W1X with BX1 Adapter Bushing, Dualvee	3	Mfg. Std. Bishop- Wisecarver	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0039	Sheet 7 of
Prepared by FORREST BLAIR	Date 11-10-82		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title POLAR MILL			

REVISIONS

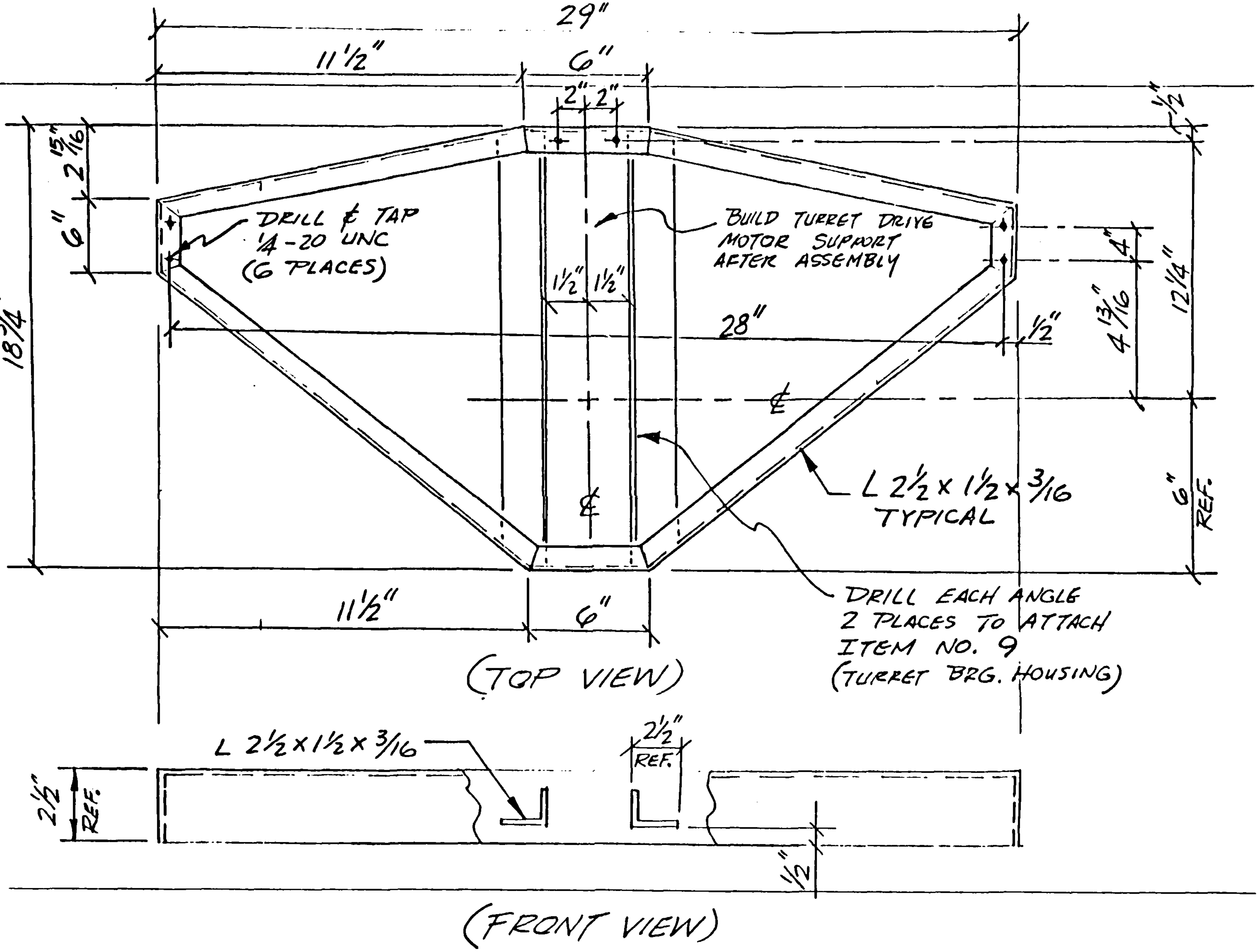
NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
49	0039	Guide Wheel - W2X with BX2 Adapter Bushing, Dualvee	4	Mfg. Std. Bishop- Wisecarver	
50	0039	Ball Nut - 3/8" Nom., RN-0375-0125	2	Mfg. Std. Raceaway	
51	0039	Collar - Set, ½" Bore	1	As Req'd.	
52	0039	Coupling - Solid, ¼" Bore, 1½" long	2	As Req'd.	
53	0039	Pipe - 3/8" Nom., Sch. 40 x 1 3/16" Long	1	As Req'd.	
54	0039	Screw - Socket Head Shoulder, ¼ - 20 UNC, 3/8" Dia. x ¼" Long Shoulder, 9X25-1216	8	Mfg. Std. Stock Drive Products	

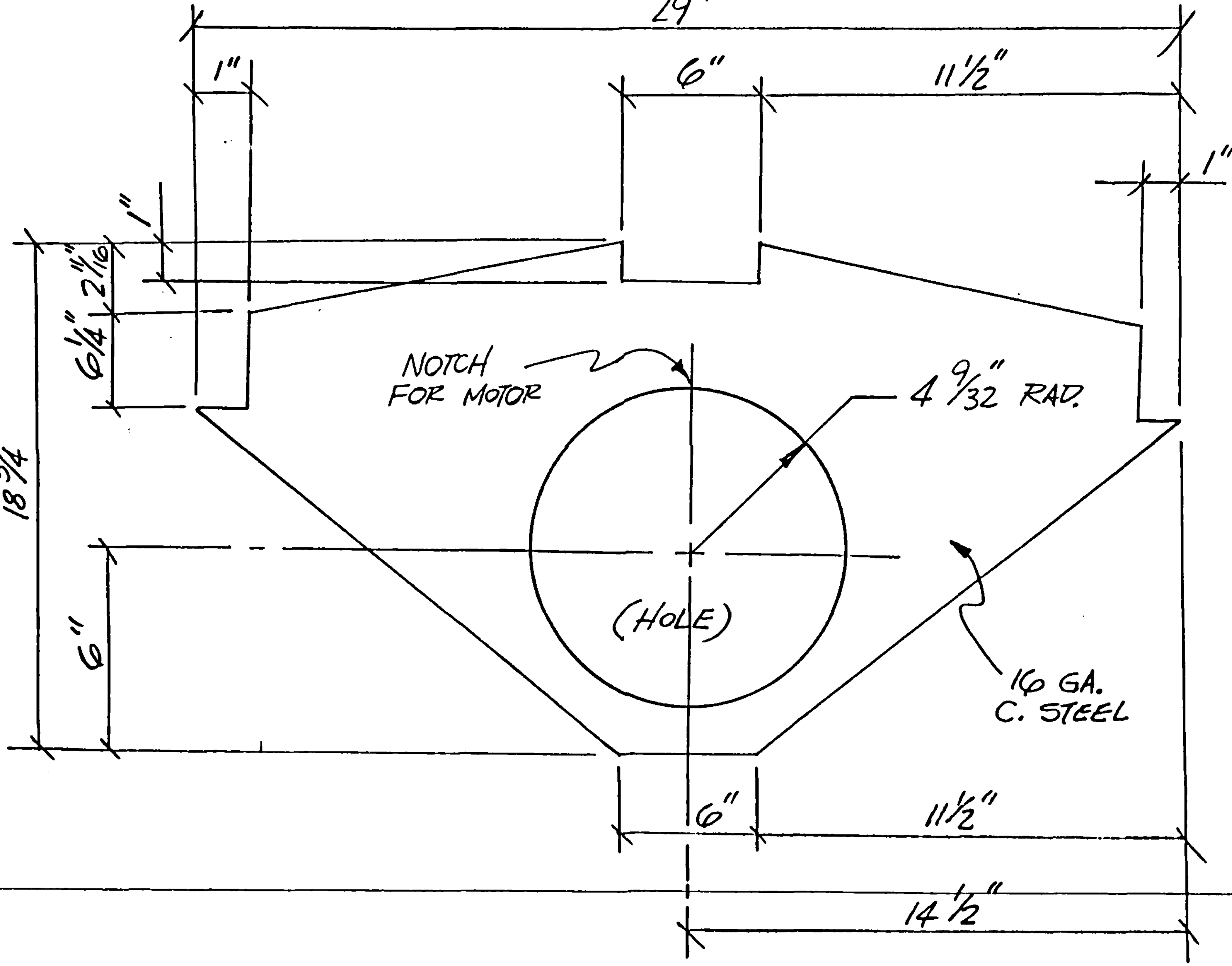
DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

SMALL 6" CUBE
POLAR MILL

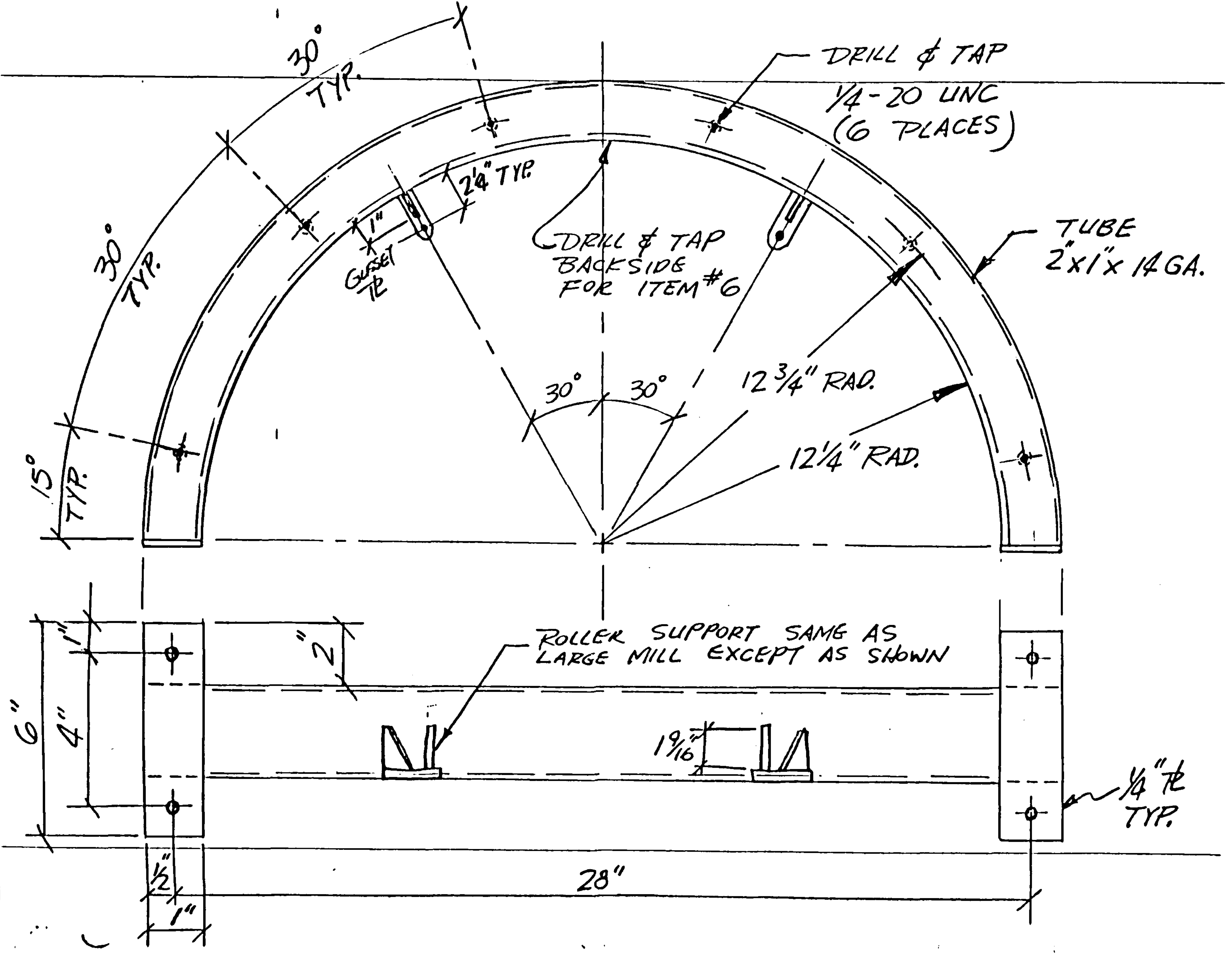
ITEM 1 | BASE FRAME | (CARBON STEEL)



ITEM 2 | BASE COVER (CARBON STEEL)

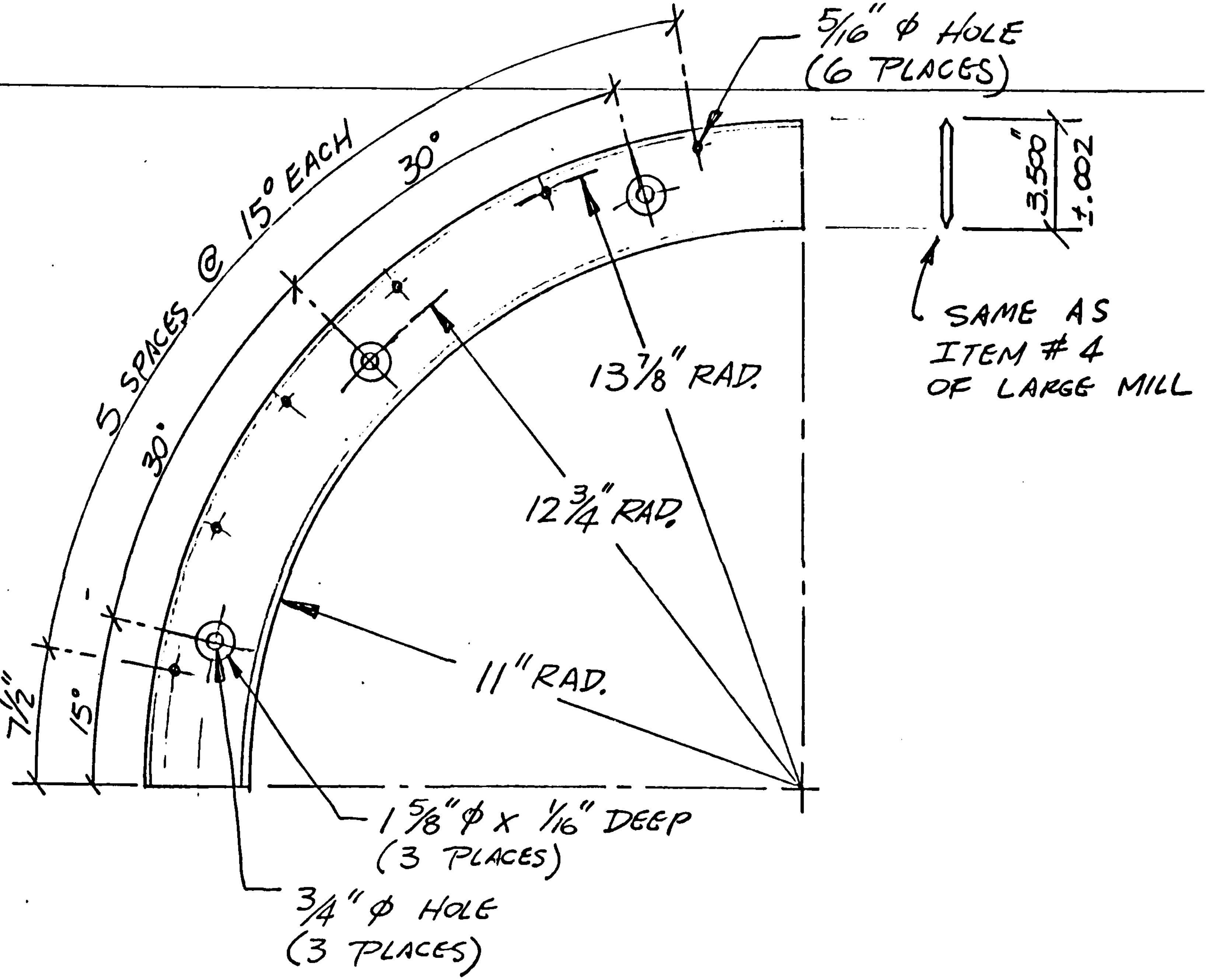


ITEM 5 | ARCH FRAME (C. STEEL)



ITEM 4 | ARCH RAIL | (C. STEEL)

2 REQUIRED

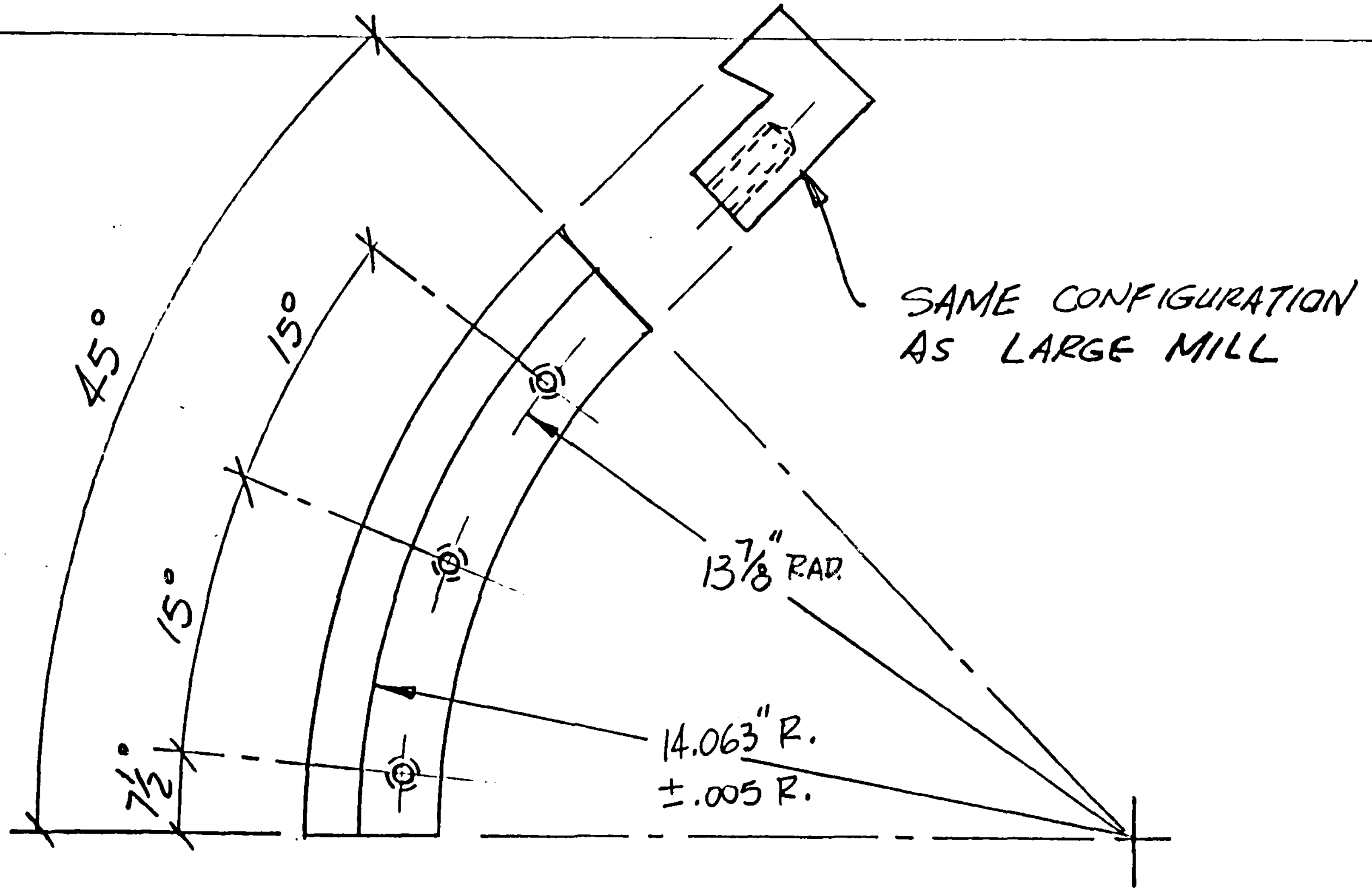


ITEM 5

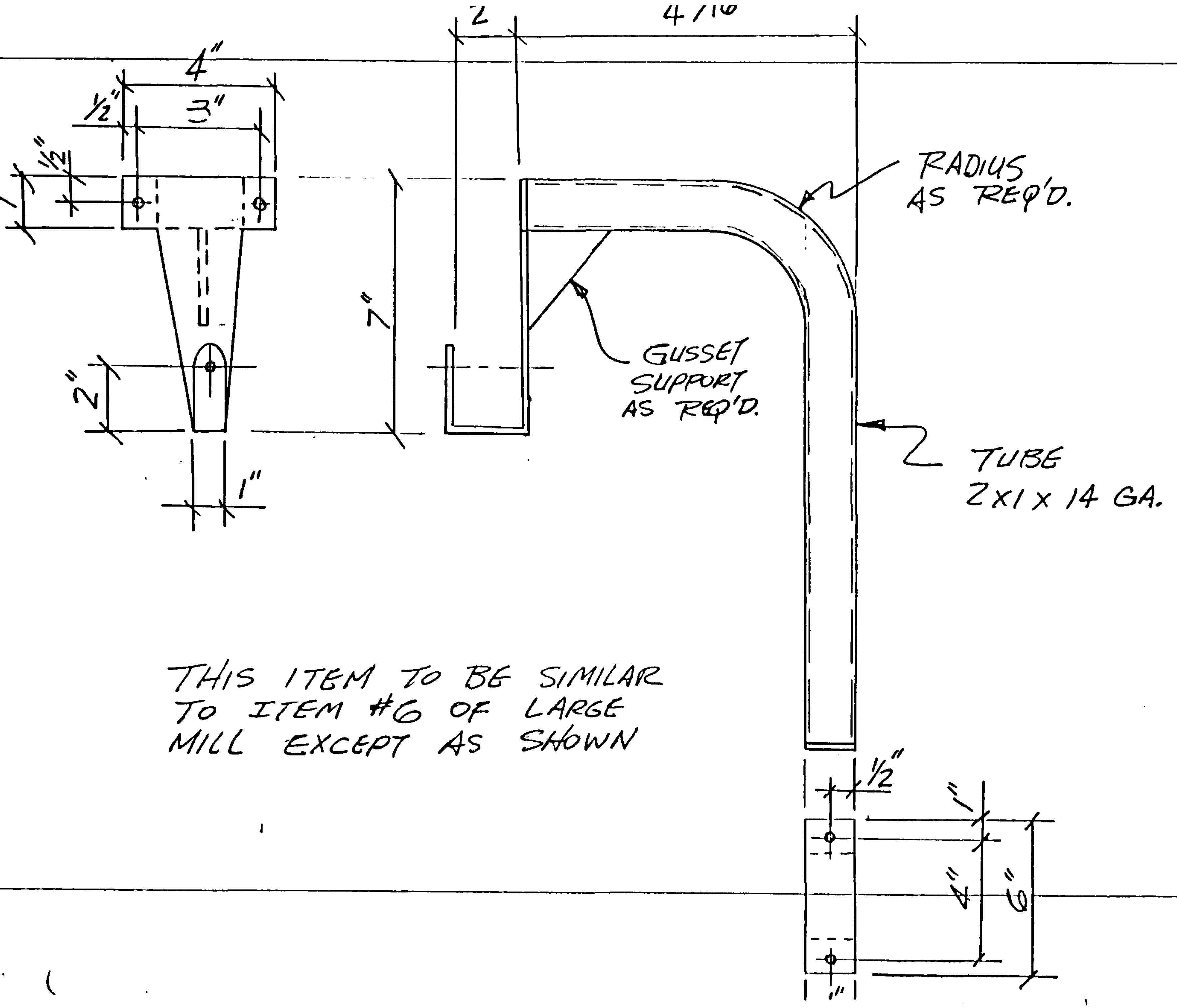
ARCH TRACK CLAMP

ALLUMINUM OR STEEL

(4 REQUIRED)



ITEM 6 | ARCH SUPPORT (C. STEEL)

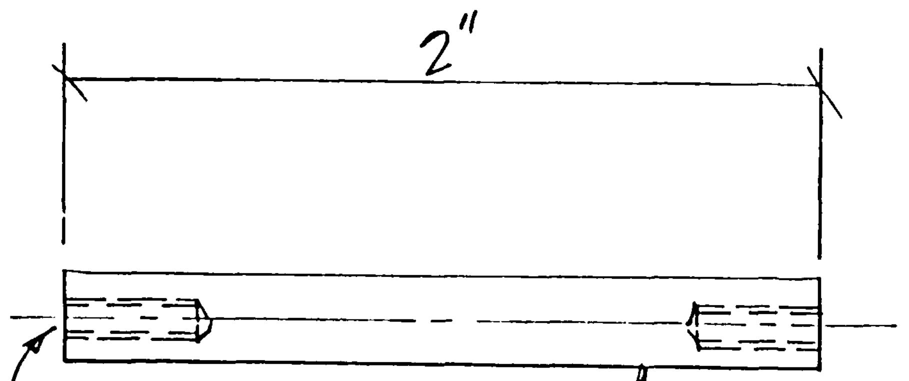


THIS ITEM TO BE SIMILAR
TO ITEM #6 OF LARGE
MILL EXCEPT AS SHOWN

ITEM 7

CABLE SUPPORT SHAFT

(C. STEEL)

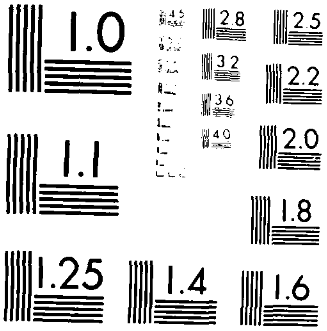


DRILL & TAP
#10-24 UNC X
1/2" DEEP (BOTH ENDS)

5/16" SQUARE BAR

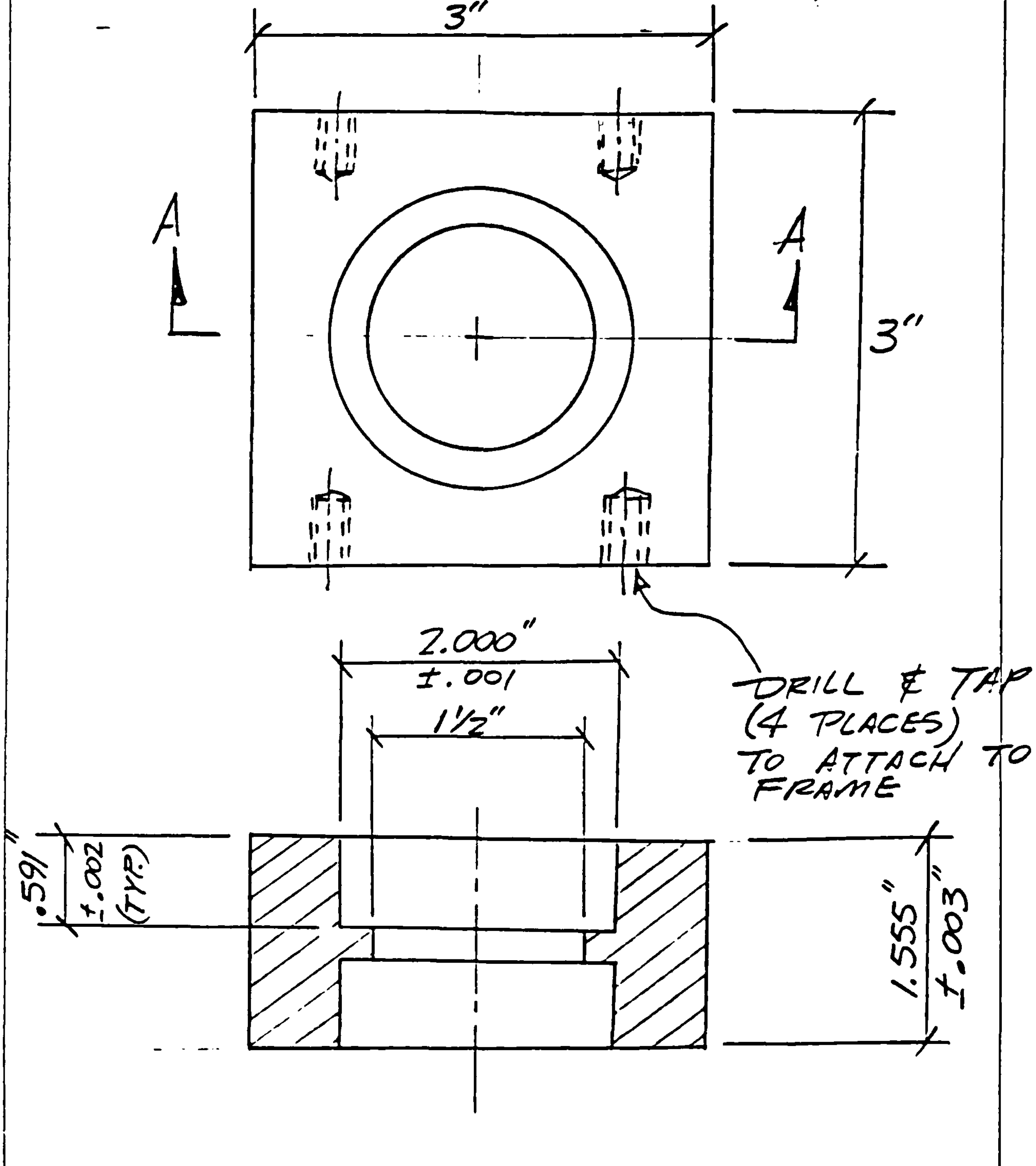
AD-A152 715 MANUFACTURING INFORMATION SYSTEM(U) BRIGHAM YOUNG UNIV 2/3
PROVO UT COMPUTER AIDED MFG LAB D K ALLEN ET AL.
26 DEC 84 AFOSR-TR-85-0275 AFOSR-82-0253

UNCLASSIFIED F/G 13/8 NL


1.0
4.5
5.0
5.6
6.3
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

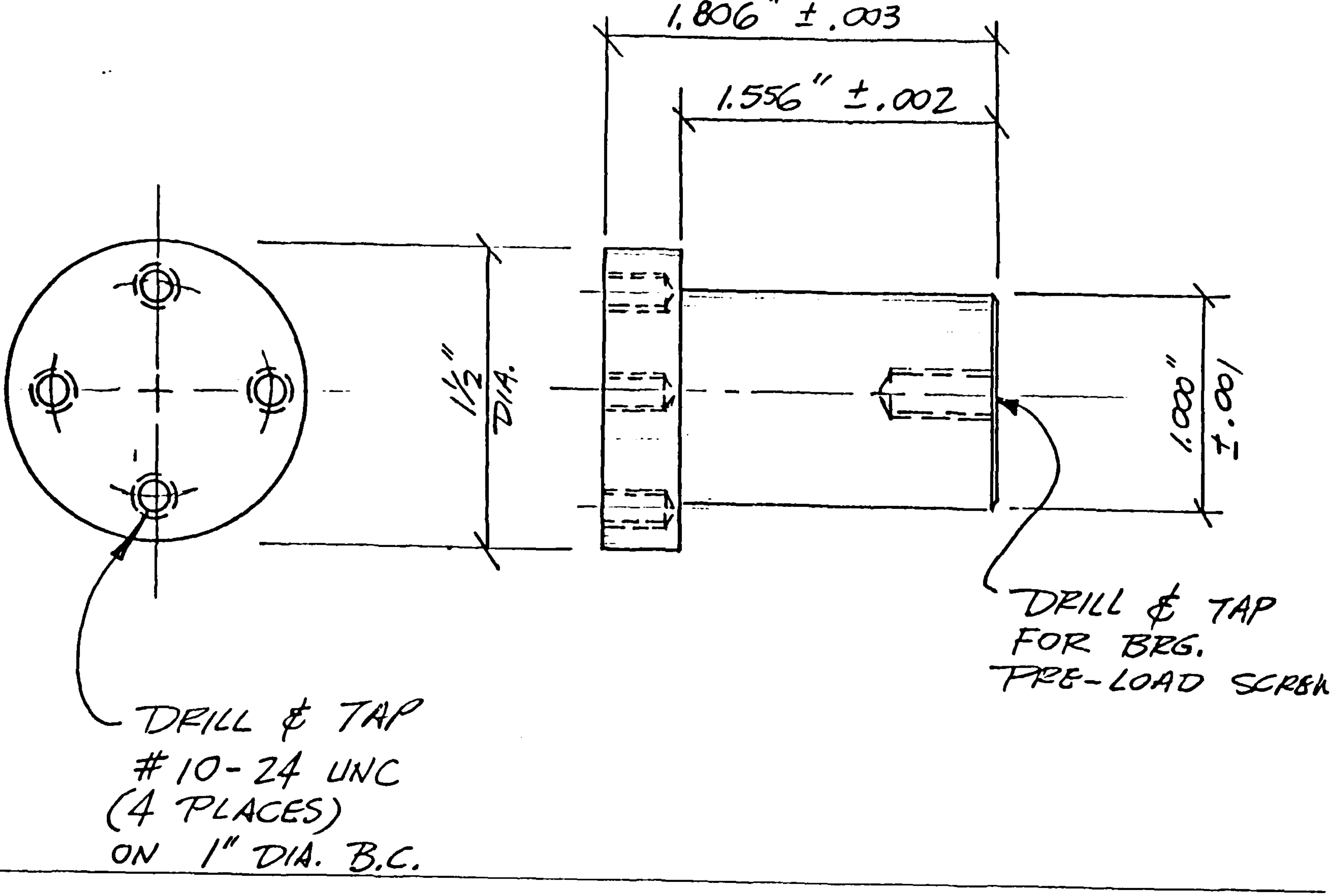
ITEM 8 — SAME AS LARGE MILL

ITEM 9 TURRET BRG. HOUSING (C. STEEL)

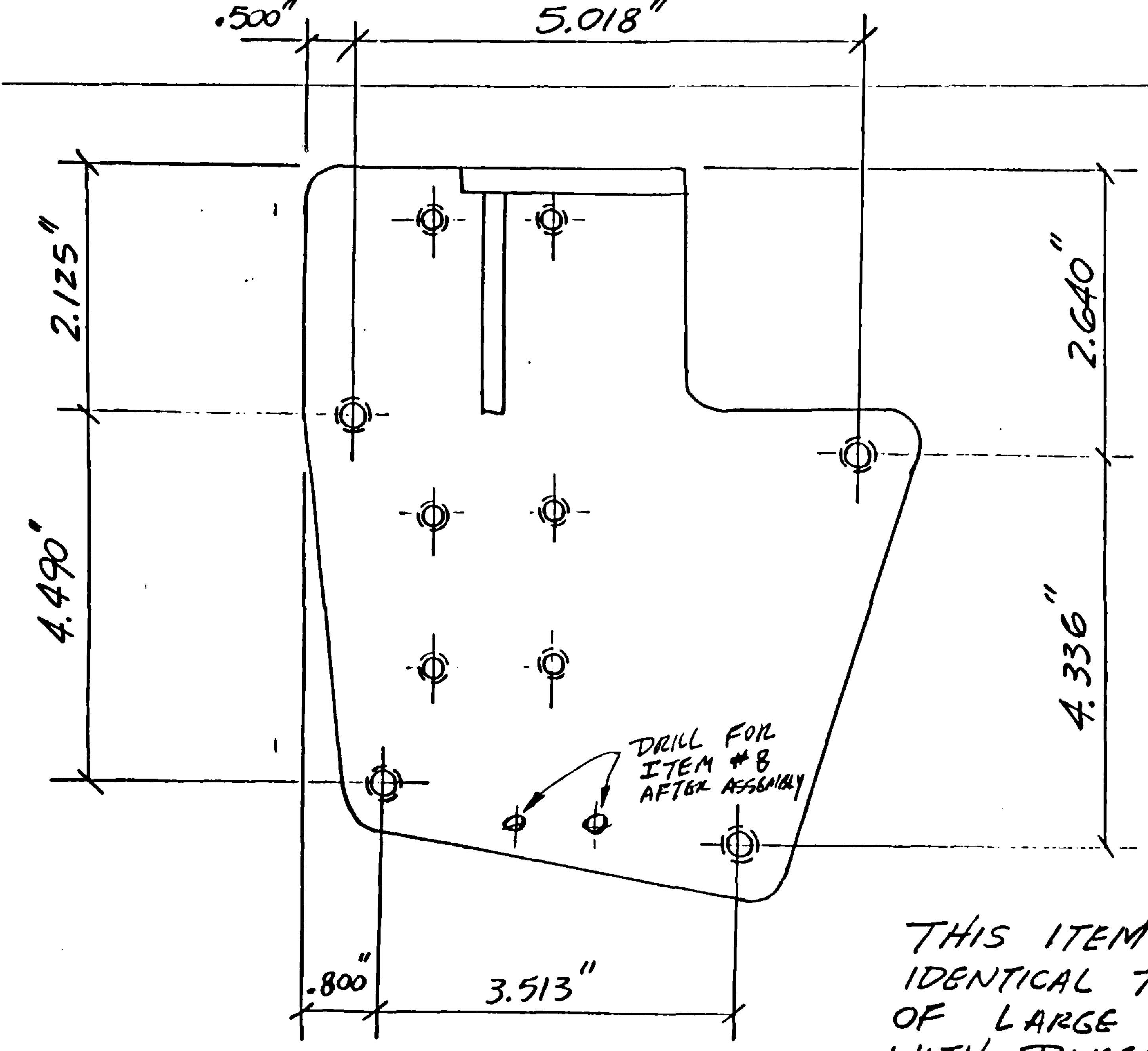


SECTION A-A

ITEM 10 TURRET SHAFT (C.STEEL)

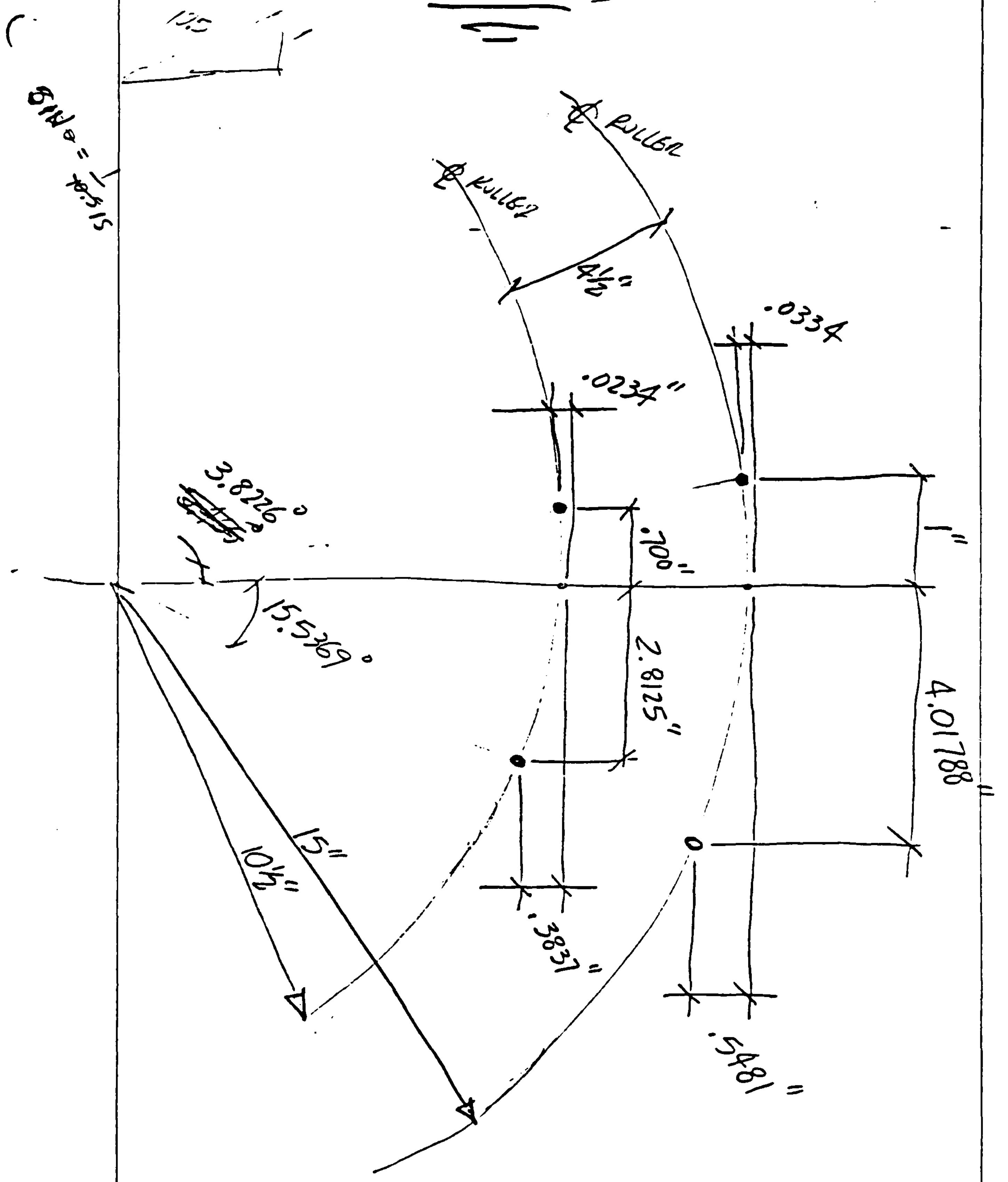

1.806" ± .003
1.556" ± .002
1½" DIA.
1.000" ±.001
DRILL ₵ TAP FOR BRG. PRE-LOAD SCREW
DRILL ₵ TAP #10-24 UNC (4 PLACES) ON 1" DIA. B.C.

ITEM 11 | TRACK DRIVE PL (C. STEEL) OR ALUM.



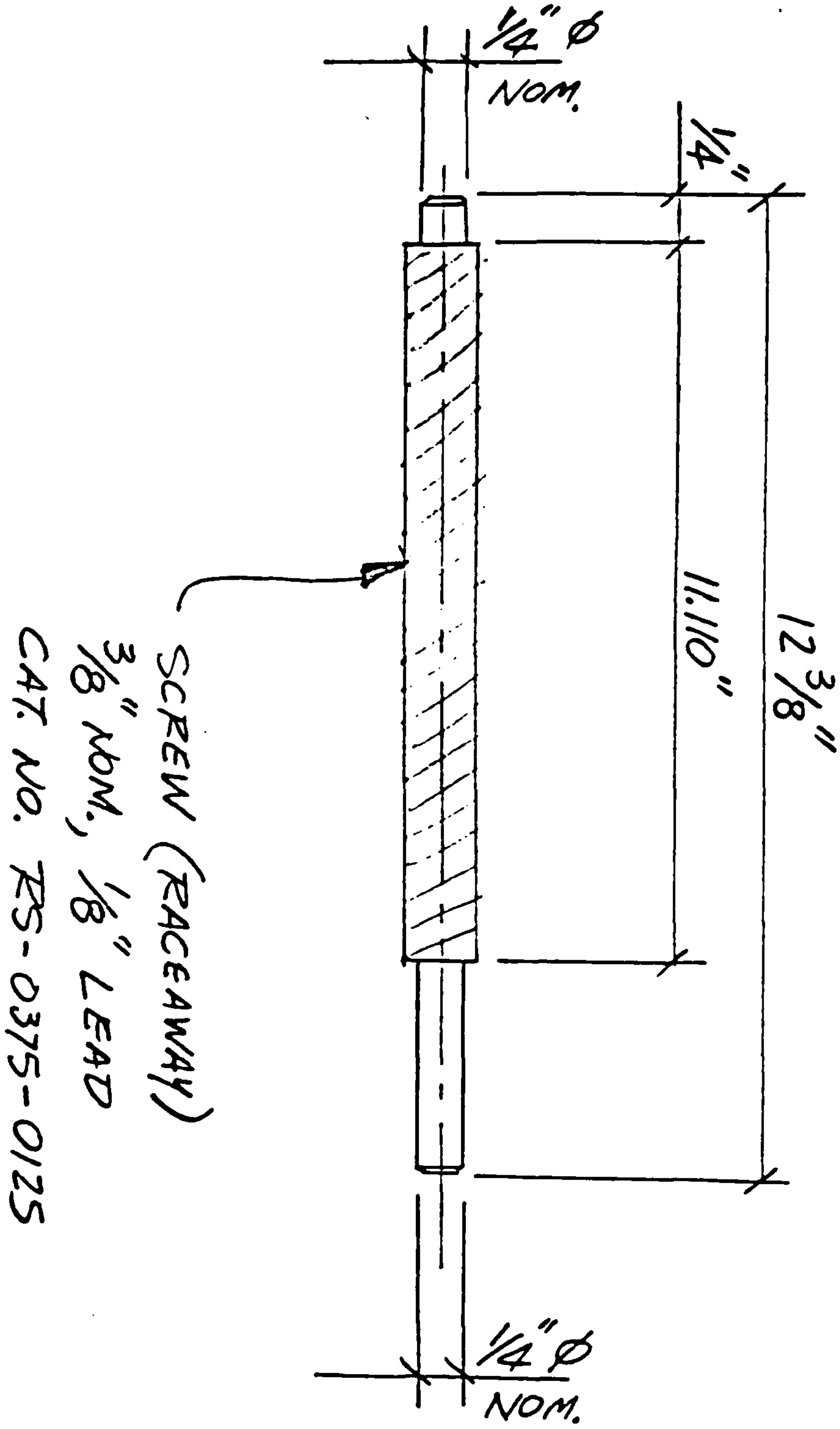
THIS ITEM TO BE IDENTICAL TO ITEM 11 OF LARGE MILL EXCEPT WITH DIMENSIONS AS SHOWN

WORK SHEET FOR ITEM 11

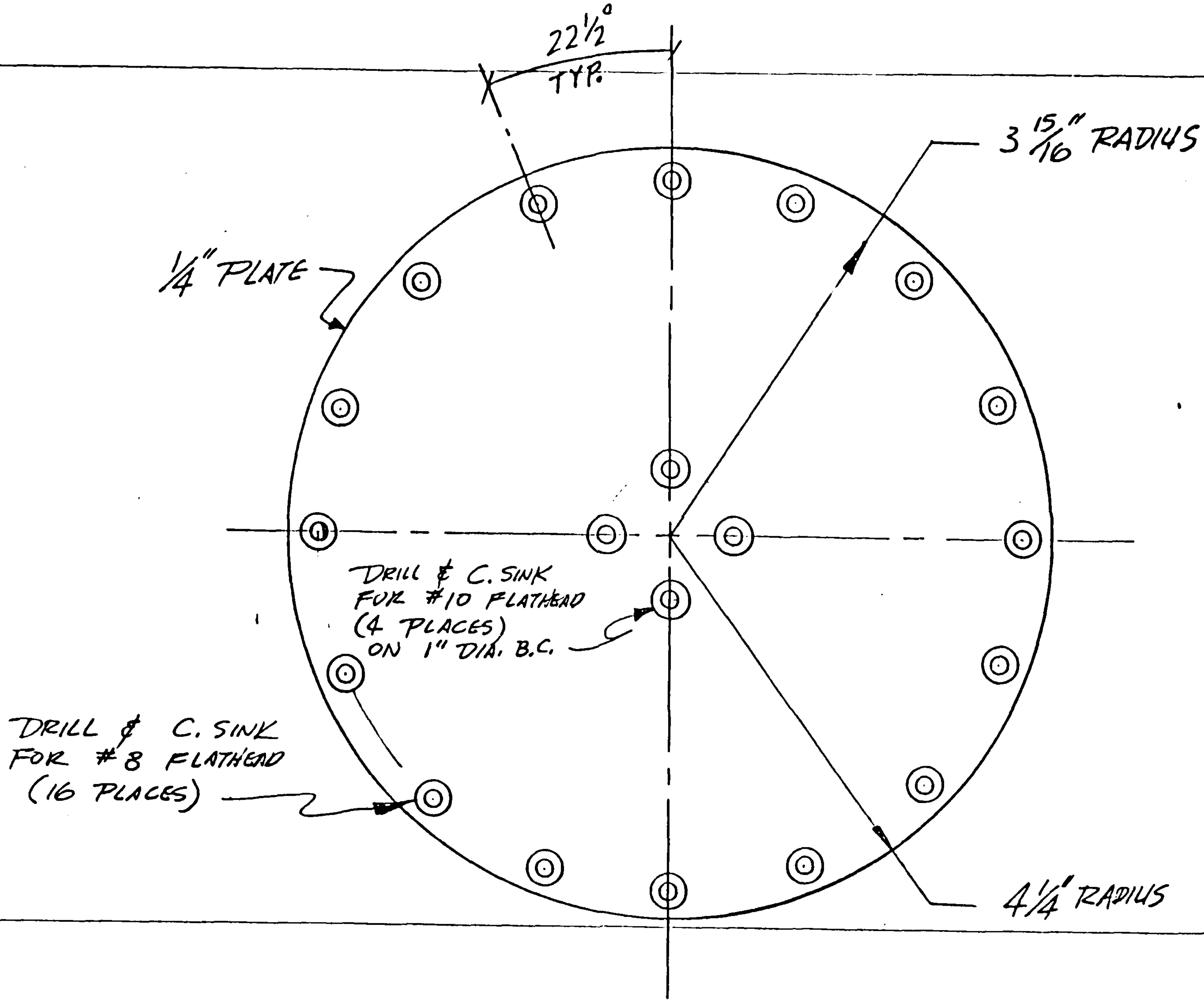


ITEM 12 — NOT NEEDED

ITEM 13 SLIDE DRIVE SCREW

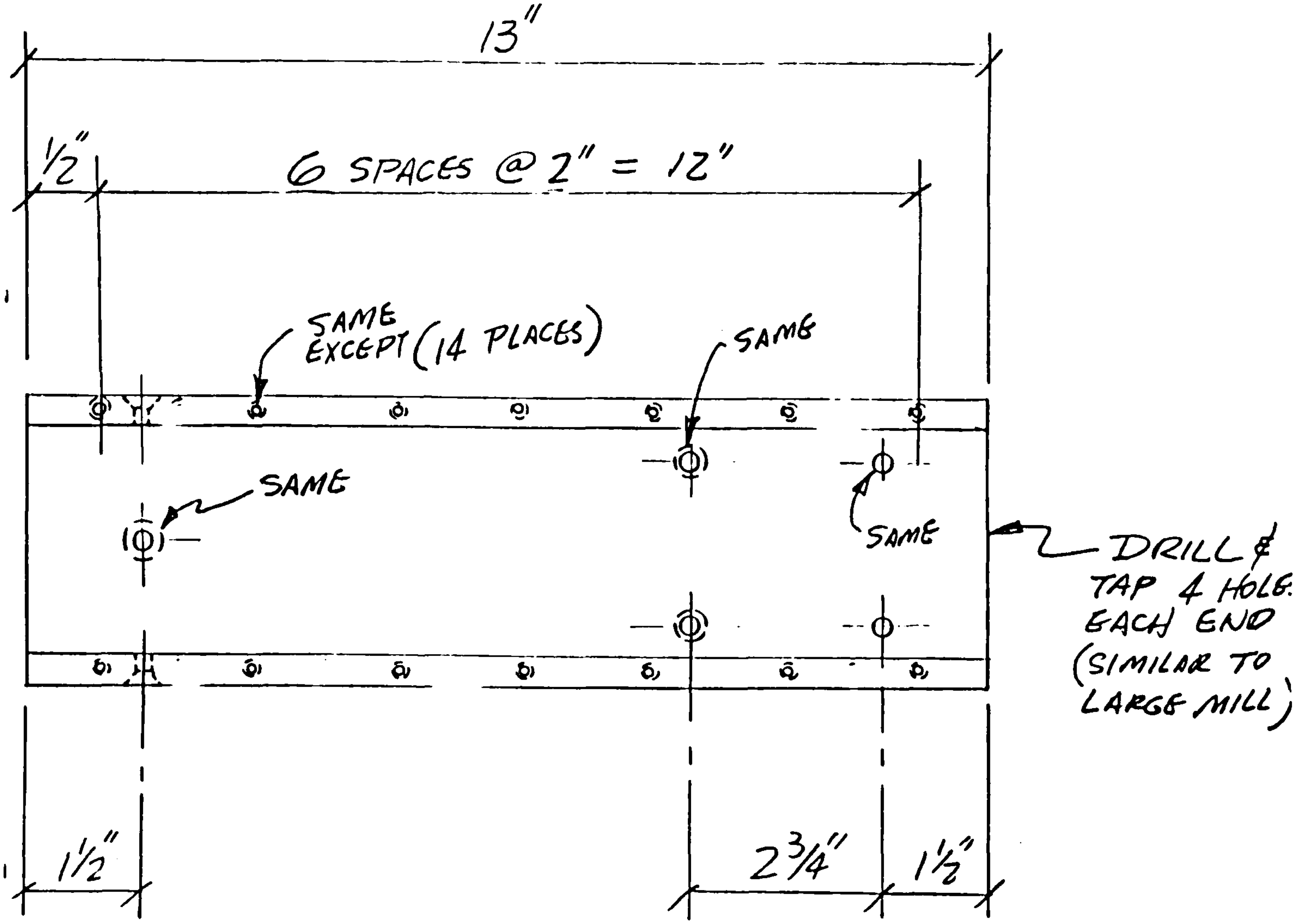


ITEM 14 TURRET PLATE (ALUMINUM)



ITEM 15 & 16 - NOT NEEDED

ITEM 17 SLIDE (ALUMINUM)

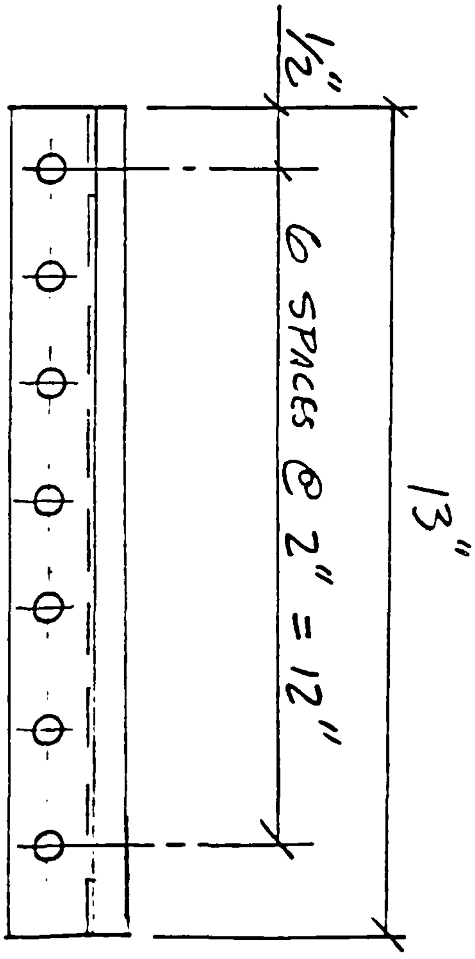


THIS ITEM TO BE IDENTICAL TO ITEMS 16 & 17 OF LARGE MILL EXCEPT AS SHOWN

ITEM 18 - SAME AS LARGE MILL

ITEM 19 CUTTER SUPPORT SHAFT
SAME AS LARGE MILL EXCEPT
PLATE IS 3"x 3" INSTEAD OF 3¼"x3"

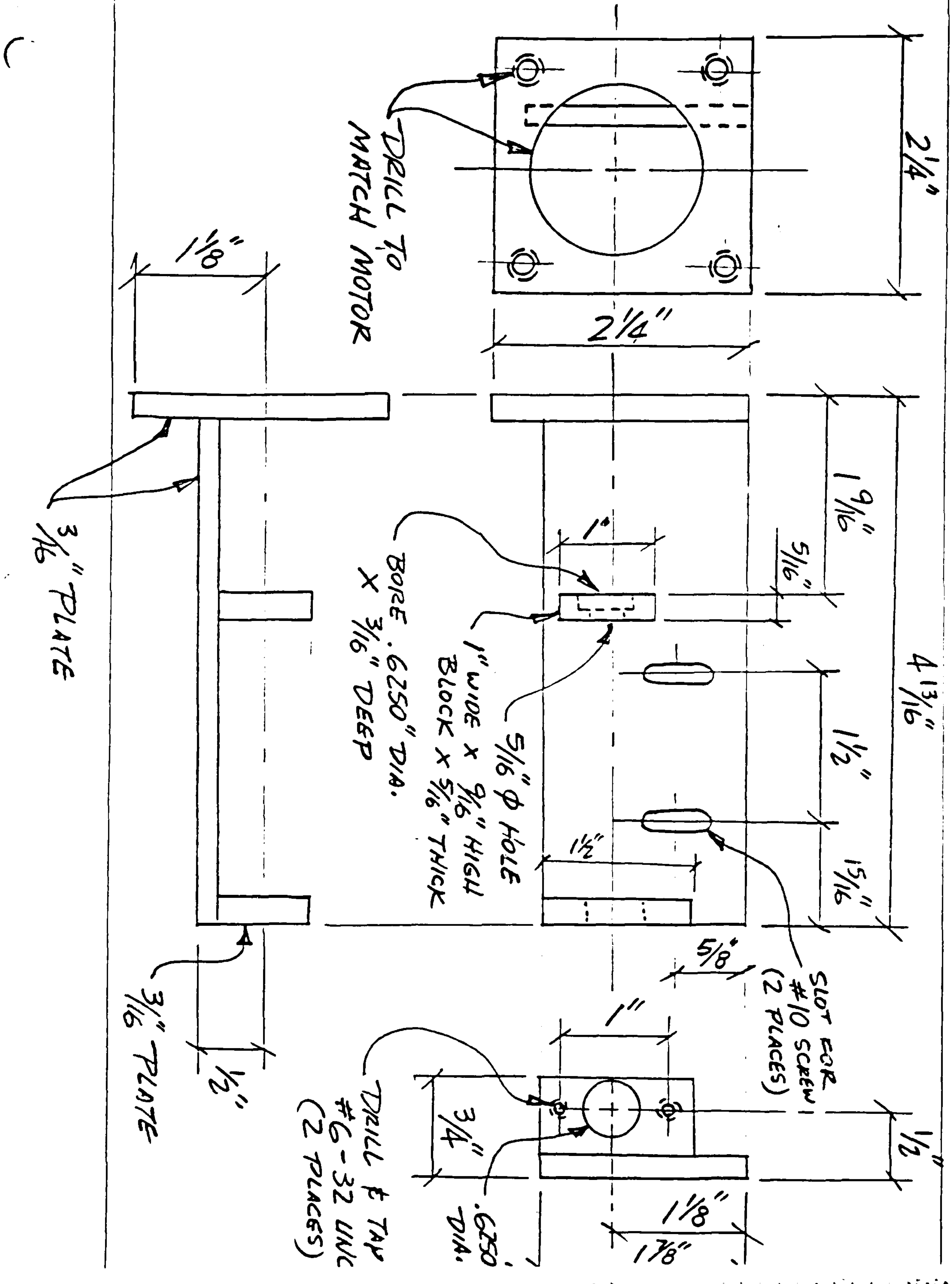
ITEM 21 SLIDE TRACK



THIS ITEM TO BE
IDENTICAL TO ITEM # 21
OF LARGE MILL EXCEPT
AS SHOWN

ITEM 20 | CUTTER DRIVE SUPPORT

(C. STEEL OR ALUMINUM)



2¼"
2¼"
DRILL TO MATCH MOTOR
1⅛"
3/16" PLATE
1 9/16"
5/16"
1"
4 13/16"
1½"
15/16"
1½"
5/16" ϕ HOLE
1" WIDE x 9/16" HIGH BLOCK x 5/16" THICK
BORE .6250" DIA. x 3/16" DEEP
SLOT FOR #10 SCREW (2 PLACES)
5/8"
3/16" PLATE
½"
1"
½"
3/4"
.6250 DIA.
DRILL & TAP #6-32 UNC (2 PLACES)
1⅛"
1⅞"

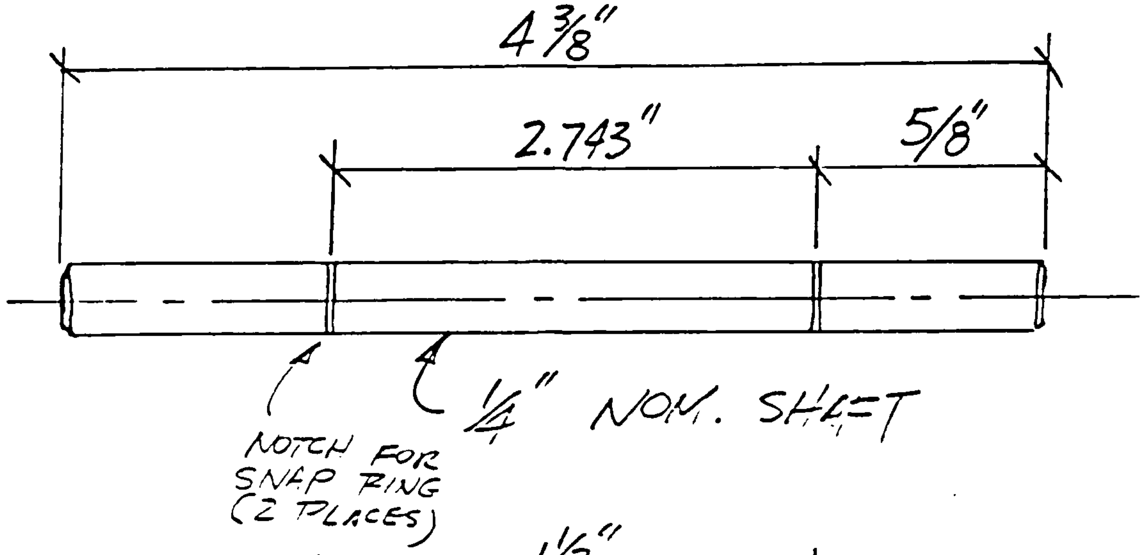
ITEMS THAT GO WITH ITEM # 20

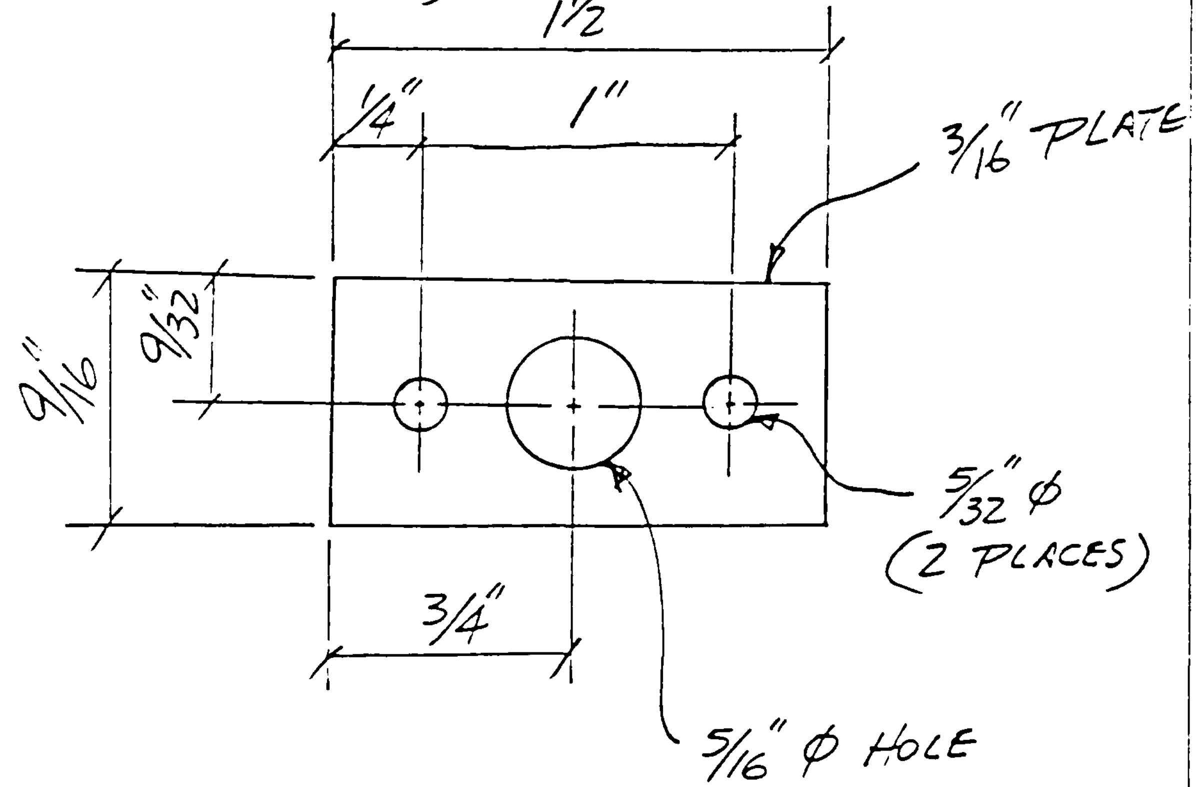
BEARING - 1/4" BORE, 5/8" NOM. OD., 2 REQUIRED

THRUST WASHER - 1/4" BORE, 2 REQUIRED

SNAP RINGS - FOR 1/4" SHAFT, 2 REQUIRED

WORM - 24 PITCH, 1/4" BORE, 1/2" NOM. P.D.,
STOCK DRIVE PRODUCTS # 1Q555-N24

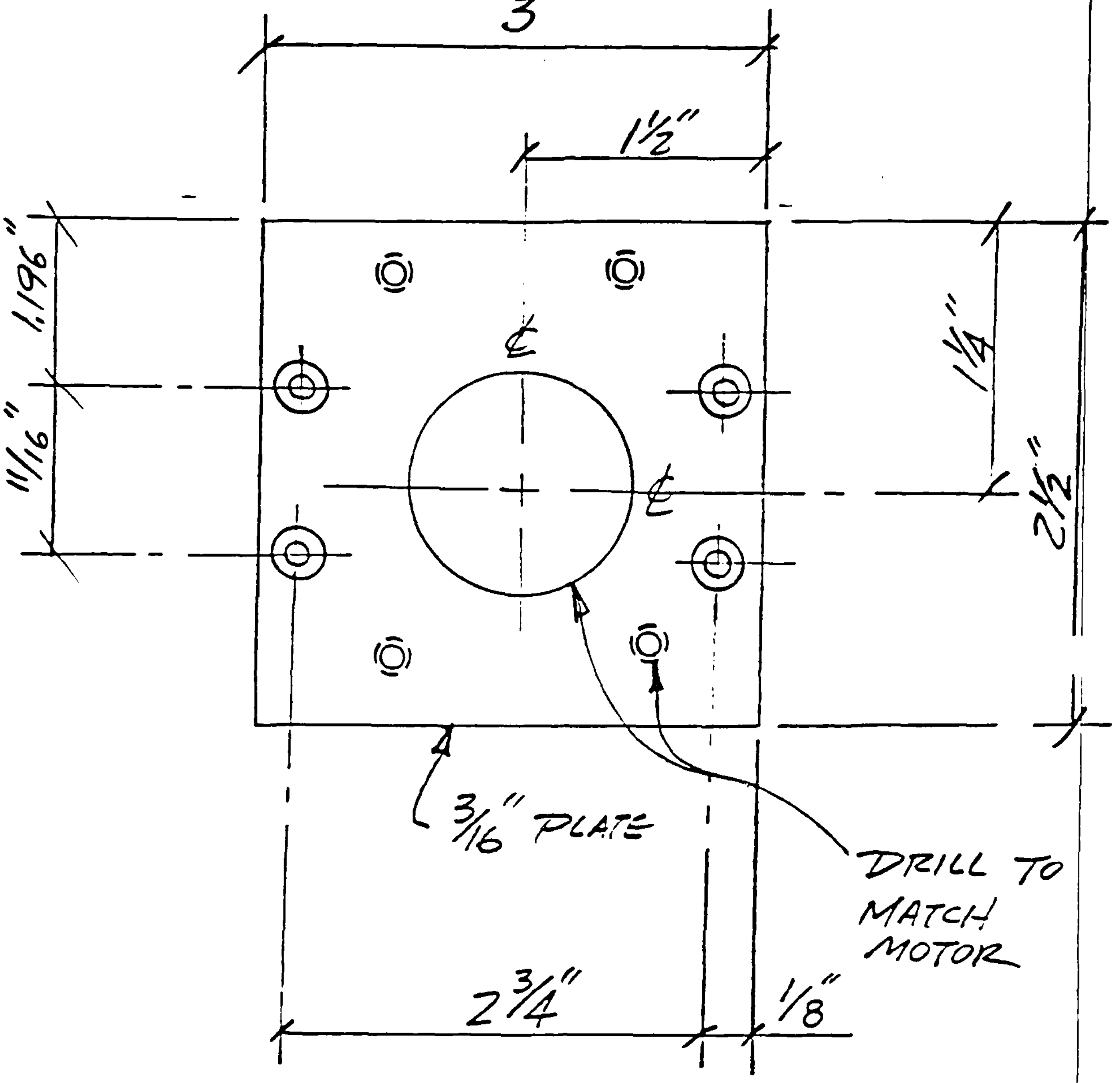




THRUST BRG. PRE-LOAD PLATE

ITEM 22 | SLIDE TOP | CAP

(ALUMINUM)

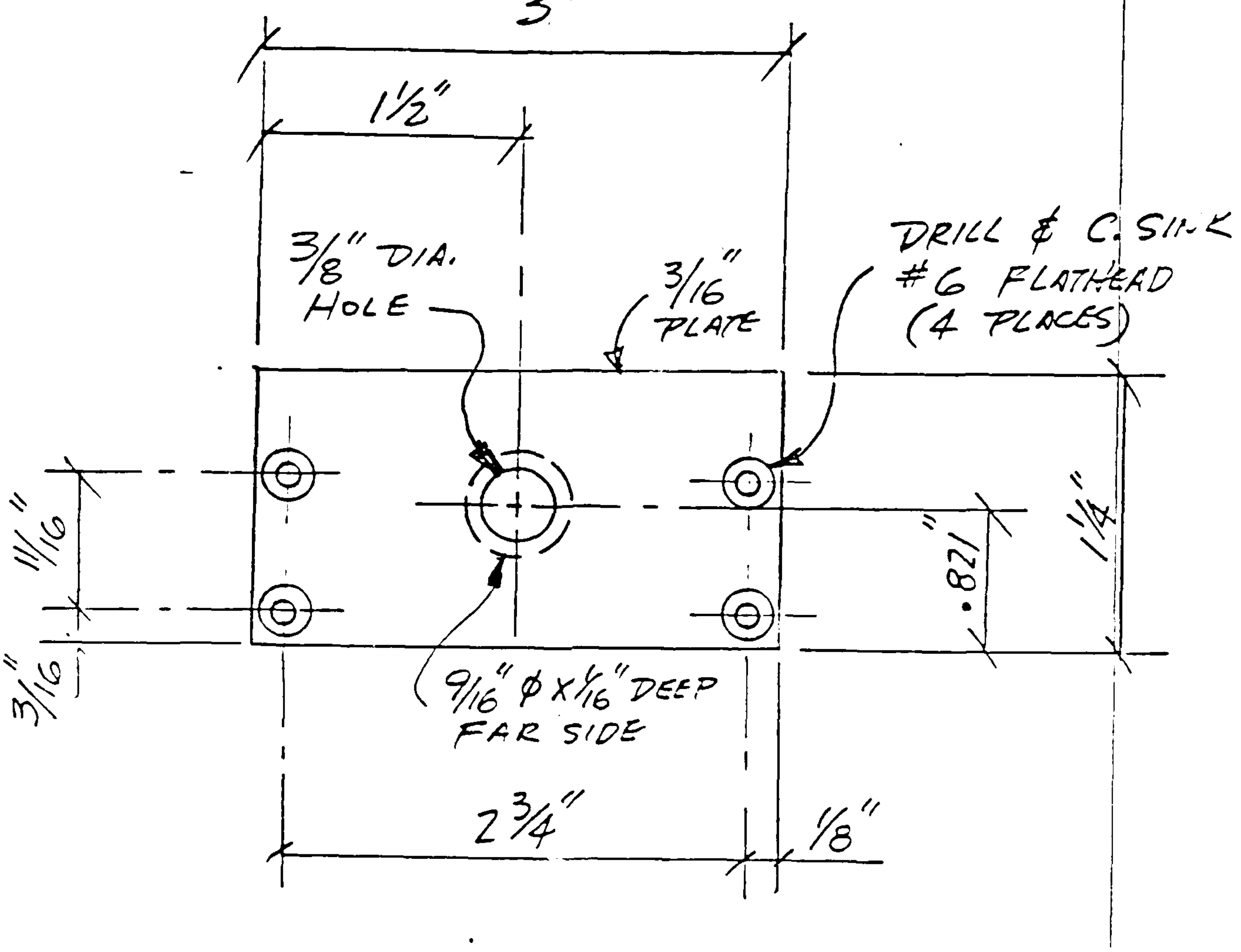


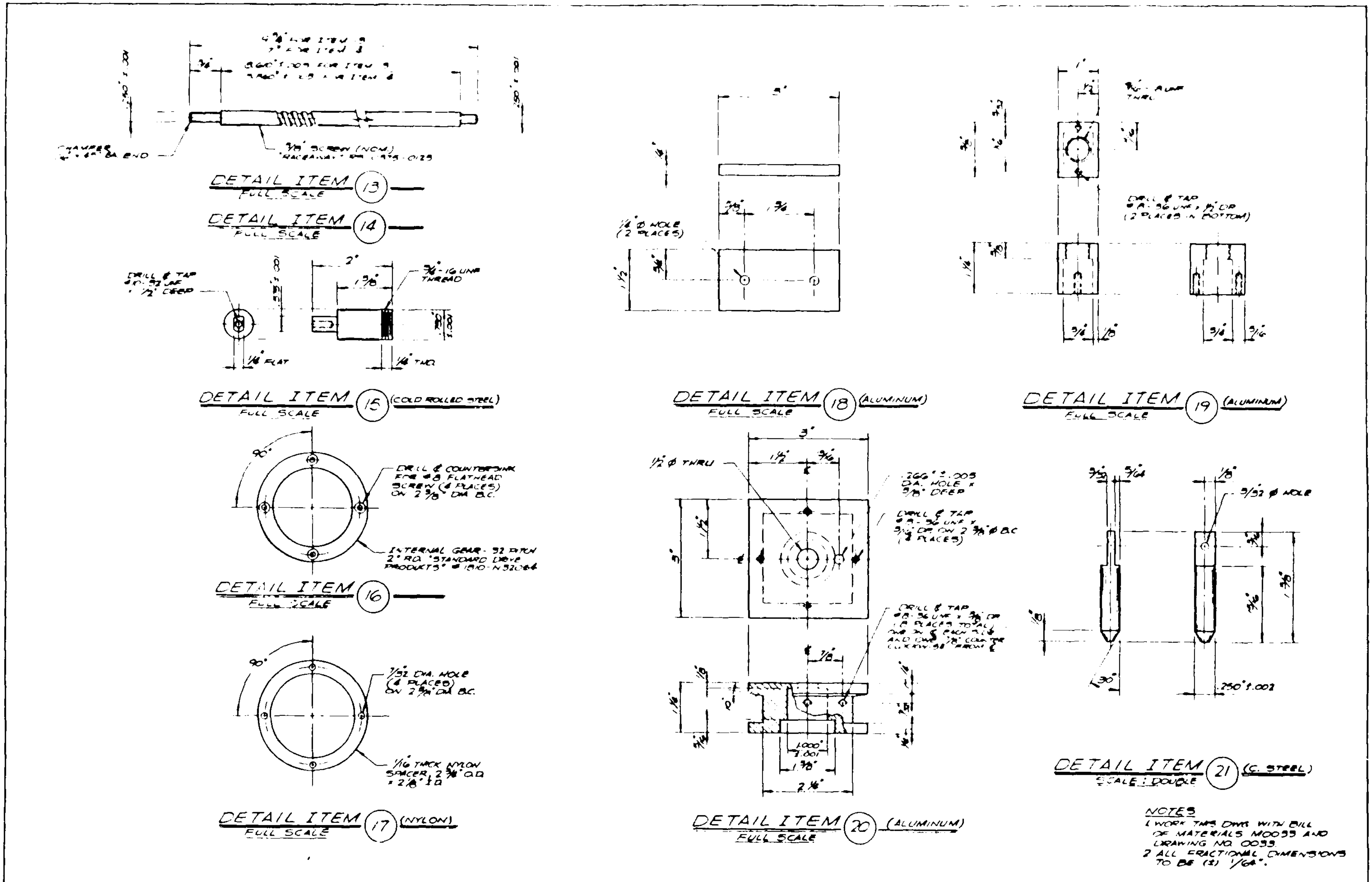
3/16" PLATE

DRILL TO MATCH MOTOR

ITEM 23 | SLIDE BOTTOM CAP

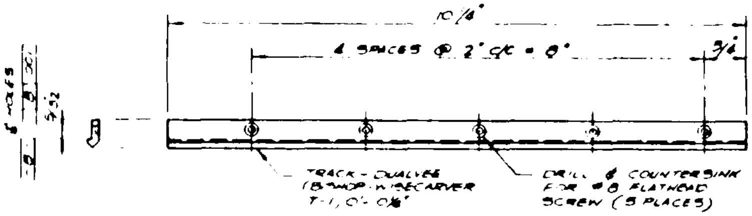
(ALUMINUM)


3"
1½"
3/8" DIA. HOLE
3/16" PLATE
DRILL & C. SINK #6 FLATHEAD (4 PLACES)
11/16"
3/16"
.821"
1¼"
9/16" ϕ X 1/16" DEEP FAR SIDE
2¾"
1/8"

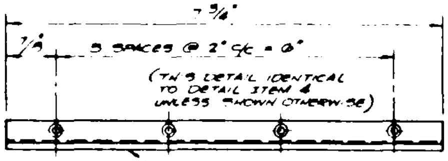

4¾" FOR ITEM 13
7" FOR ITEM 14
.3/16"
.860"±.005 FOR ITEM 13
.860"±.005 FOR ITEM 14
CHAMFER 1/64" × 45° EA END
3/8" SCREW (NOM) "RACEWAY" RS-0375-0125
DETAIL ITEM 13
FULL SCALE
DETAIL ITEM 14
FULL SCALE
DRILL & TAP 4-40 UNF × ½" DEEP
2"
1⅜"
3/4-16 UNF THREAD
¼" FLAT
¼" THD
DETAIL ITEM 15 (COLD ROLLED STEEL)
FULL SCALE
90°
DRILL & COUNTERSINK FOR #8 FLATHEAD SCREW (4 PLACES) ON 2⅞" DIA B.C.
INTERNAL GEAR - 32 PITCH 2" P.D. "STANDARD DRIVE PRODUCTS" # 1810-N32064
DETAIL ITEM 16
FULL SCALE
7/32 DIA. HOLE (4 PLACES) ON 2⅞" DIA B.C.
1/16" THICK NYLON SPACER, 2⅞" O.D. × 2⅛" I.D.
DETAIL ITEM 17 (NYLON)
FULL SCALE
3"
¼"
3/16"
1¾
¼" Ø HOLE (2 PLACES)
1½"
DETAIL ITEM 18 (ALUMINUM)
FULL SCALE
1"
½"
3/4-16 UNF THRU
DRILL & TAP #8-36 UNF × ½" DP (2 PLACES IN BOTTOM)
3/16
⅛"
DETAIL ITEM 19 (ALUMINUM)
FULL SCALE
3"
1½"
3/16"
½" Ø THRU
.266"±.005 DIA. HOLE × 5/16" DEEP
DRILL & TAP #8-36 UNF × 3/16" DP. ON 2 3/16" Ø BC (4 PLACES)
DRILL & TAP #8-36 UNF × 3/16" DP (8 PLACES TOTAL, ONE IN ℄ EACH SIDE AND ONE 7/8" COUNTER CLOCKWISE 90° FROM ℄)
7/8"
1.000" ±.001
1⅜"
2 ¼"
DETAIL ITEM 20 (ALUMINUM)
FULL SCALE
3/32
3/64
⅛"
3/32 Ø HOLE
30°
.250"±.002
DETAIL ITEM 21 (C. STEEL)
SCALE: DOUBLE

NOTES
1. WORK THIS DWG WITH BILL OF MATERIALS M0033 AND DRAWING NO. 0033.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".

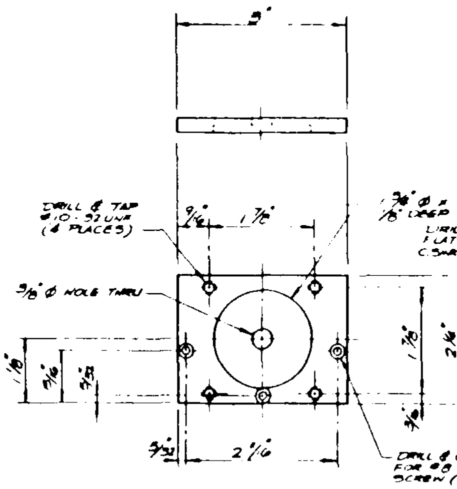
AUGUST 2, 1982 CAD-CAM DEPT.	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	LATHE	DETAIL ITEM 13,14,15,16,17,18,19,20 & 21		FORREST BLAIR	0037


10 1/4"
4 SPACES @ 2" C/C = 8"
3/4"
8 HOLES
5/32
TRACK - DUALVEE (BISHOP-WISECARVER T-1, 0'-10 1/4"
DRILL & COUNTERSINK FOR #8 FLATHEAD SCREW (5 PLACES)

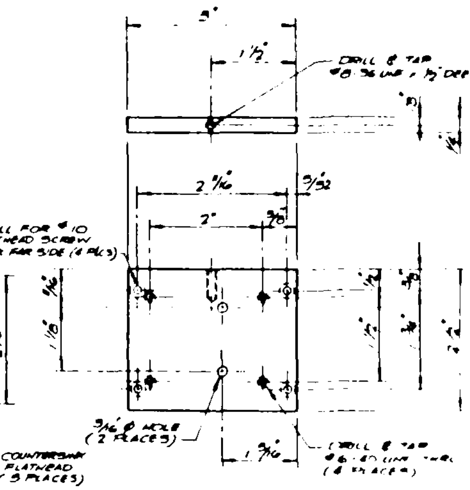
DETAIL ITEM (4) ONE AS SHOWN ONE OPPOSITE
FULL SCALE


7 3/4"
7/8"
3 SPACES @ 2" C/C = 6"
(THIS DETAIL IDENTICAL TO DETAIL ITEM 4 UNLESS SHOWN OTHERWISE)
TRACK - DUALVEE (BISHOP-WISECARVER) T-1, 0'-7 3/4"

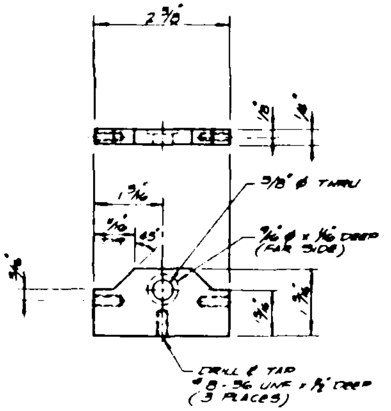
DETAIL ITEM (5) ONE AS SHOWN ONE OPPOSITE
FULL SCALE



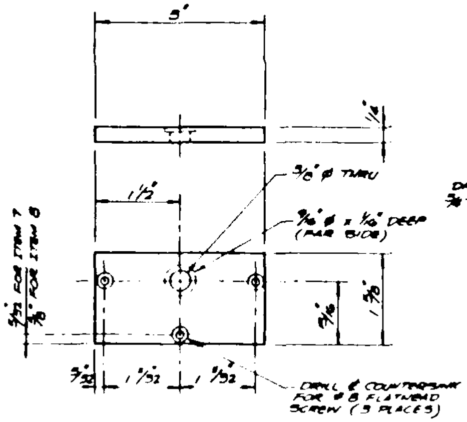
DETAIL ITEM (9) (ALUMINUM)
FULL SCALE


3"
1 1/2"
DRILL & TAP #8-36 UNF x 1/2" DEEP
DRILL FOR #10 FLATHEAD SCREW C.SNK FAR SIDE (4 PLCS)
2 11/16"
5/32
2"
3/8"
9/16
1 1/8
1/2"
3/8"
3/4"
3/16" Ø HOLE (2 PLACES)
1 3/16
DRILL & TAP #6-40 UNF THRU (4 PLACES)

DETAIL ITEM (10) (ALUMINUM)
FULL SCALE

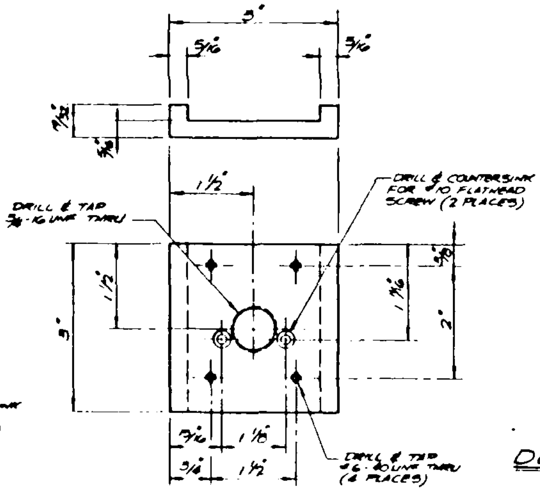

2 3/8"
1/8"
1/4"
3/8" Ø THRU
1 3/16
5/16
45°
9/16" Ø x 1/16" DEEP (FAR SIDE)
3/4"
3/8"
1 3/8"
DRILL & TAP #8-36 UNF x 1/2" DEEP (3 PLACES)

DETAIL ITEM (6) (ALUMINUM)
FULL SCALE

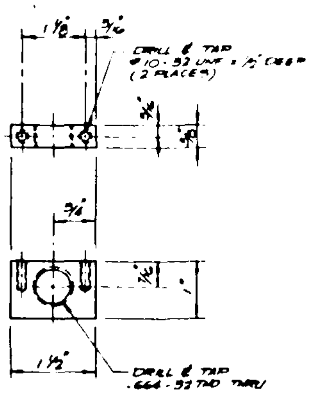

3"
1/4"
3/8" Ø THRU
1 1/2"
9/16" Ø x 1/16" DEEP (FAR SIDE)
5/32" FOR ITEM 7
3/8" FOR ITEM 8
3/4"
1 3/8"
5/32
1 5/32
1 5/32
DRILL & COUNTERSINK FOR #8 FLATHEAD SCREW (3 PLACES)

DETAIL ITEM (7) (ALUMINUM)
FULL SCALE

DETAIL ITEM (8) (ALUMINUM)
FULL SCALE


3"
5/16
5/16
7/32
5/16
1 1/2"
DRILL & TAP 3/4-16 UNF THRU
DRILL & COUNTERSINK FOR #10 FLATHEAD SCREW (2 PLACES)
3"
1 1/2
3/8
1 9/16
2"
5/16
1 1/8
3/4
1 1/2
DRILL & TAP #6-40 UNF THRU (4 PLACES)

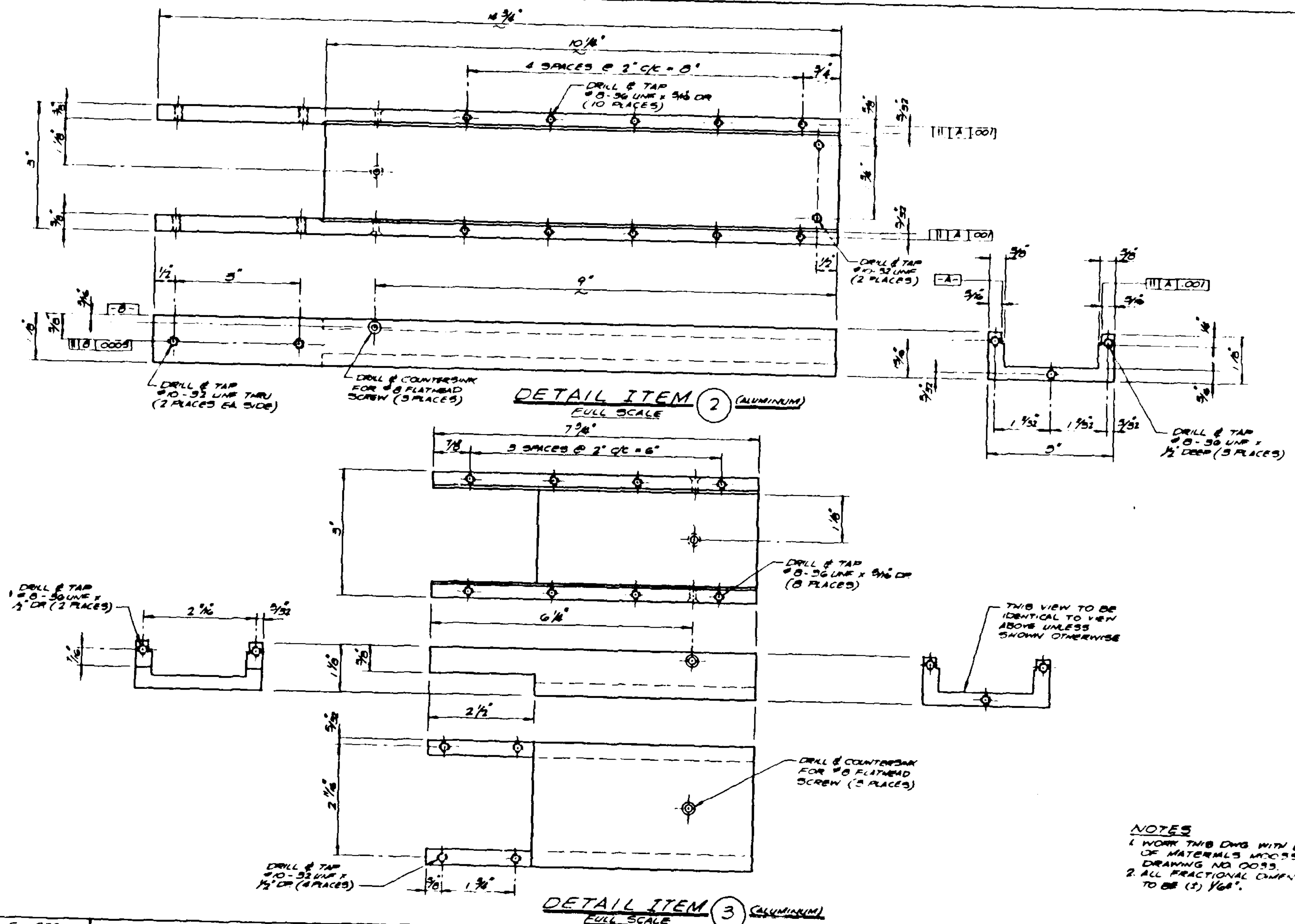
DETAIL ITEM (11) (ALUMINUM)
FULL SCALE


1 1/8
3/16
DRILL & TAP #10-32 UNF x 1/2" DEEP (2 PLACES)
3/4
3/8
3/4
7/16
1"
1 1/2"
DRILL & TAP .664-32 TPD THRU

DETAIL ITEM (12) (ALUMINUM)
FULL SCALE

NOTES
1. WORK THIS DWG WITH BILL OF MATERIALS MDC33 AND DRAWING NO. 0033.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".

AUGUST 2, 1982 CAD-CAM DEPT.	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	LATHE	DETAIL ITEM 4,5,6,7,8,9,10,11 & 12		FORREST BLAIR	0036



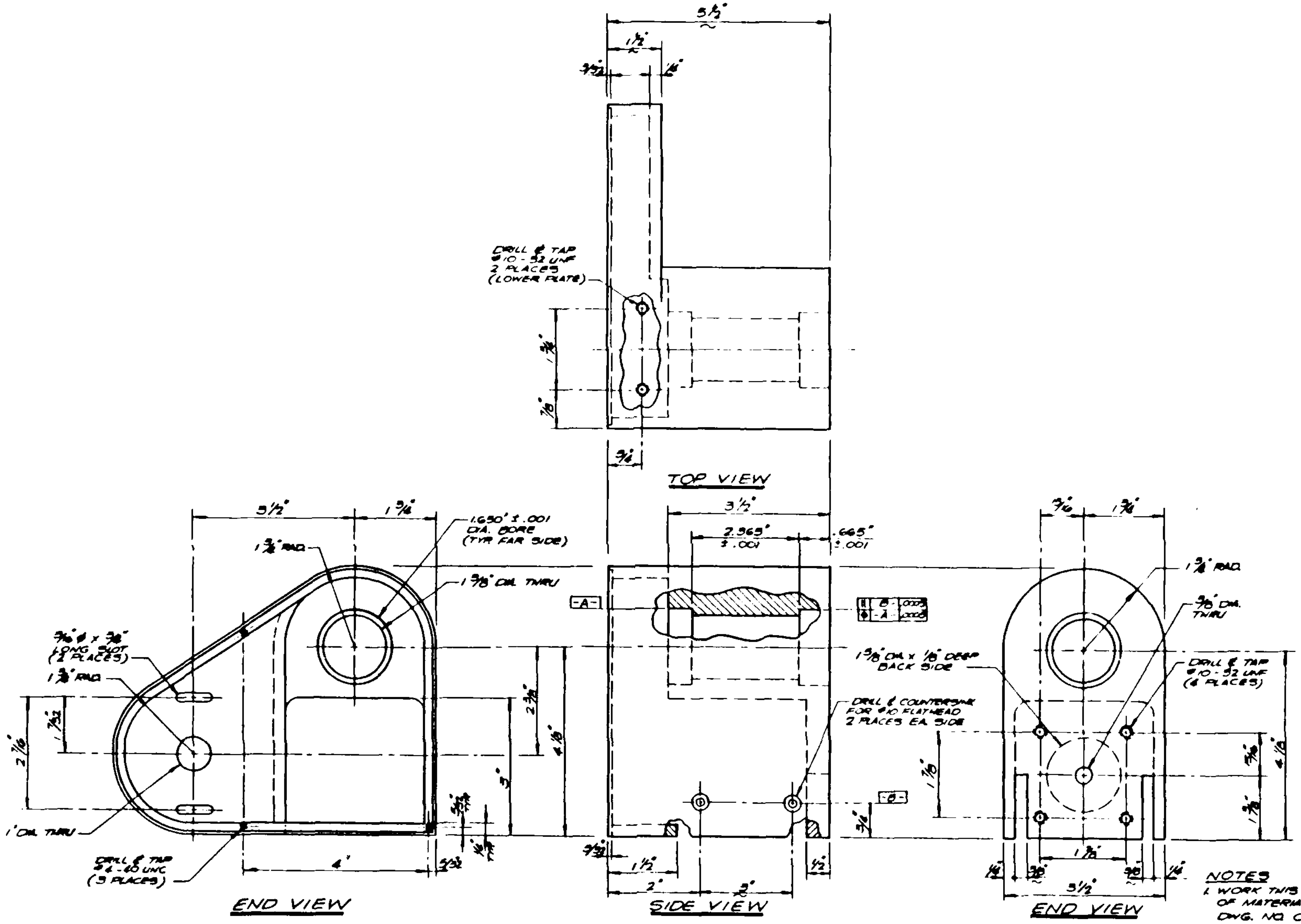
14 3/4"
10 1/4"
4 SPACES @ 2" C/C = 8"
3/4"
DRILL & TAP #8-36 UNF x 5/16 DP (10 PLACES)
3/8"
5/32
3"
// A .001
DRILL & TAP #10-32 UNF (2 PLACES)
1/2"
5"
9"
-B-
// B .0005
DRILL & TAP #10-32 UNF THRU (2 PLACES EA SIDE)
DRILL & COUNTERSINK FOR #8 FLATHEAD SCREW (3 PLACES)
-A-
5/16
1 1/8
1 15/32
3/32
DRILL & TAP #8-36 UNF x 1/2" DEEP (3 PLACES)
7 3/16"
7/8
3 SPACES @ 2" C/C = 6"
DRILL & TAP #8-36 UNF x 5/16 DP (8 PLACES)
DRILL & TAP #8-36 UNF x 1/2" DP (2 PLACES)
2 7/16
6 1/8"
2 1/2"
THIS VIEW TO BE IDENTICAL TO VIEW ABOVE UNLESS SHOWN OTHERWISE
2 1/16
DRILL & COUNTERSINK FOR #8 FLATHEAD SCREW (3 PLACES)
DRILL & TAP #10-32 UNF x 1/2" DP (4 PLACES)
3/8
1 3/4"

DETAIL ITEM (2) (ALUMINUM)
FULL SCALE

DETAIL ITEM (3) (ALUMINUM)
FULL SCALE

NOTES
1. WORK THIS DWG WITH BILL OF MATERIALS M0035 AND DRAWING NO. 0035.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".

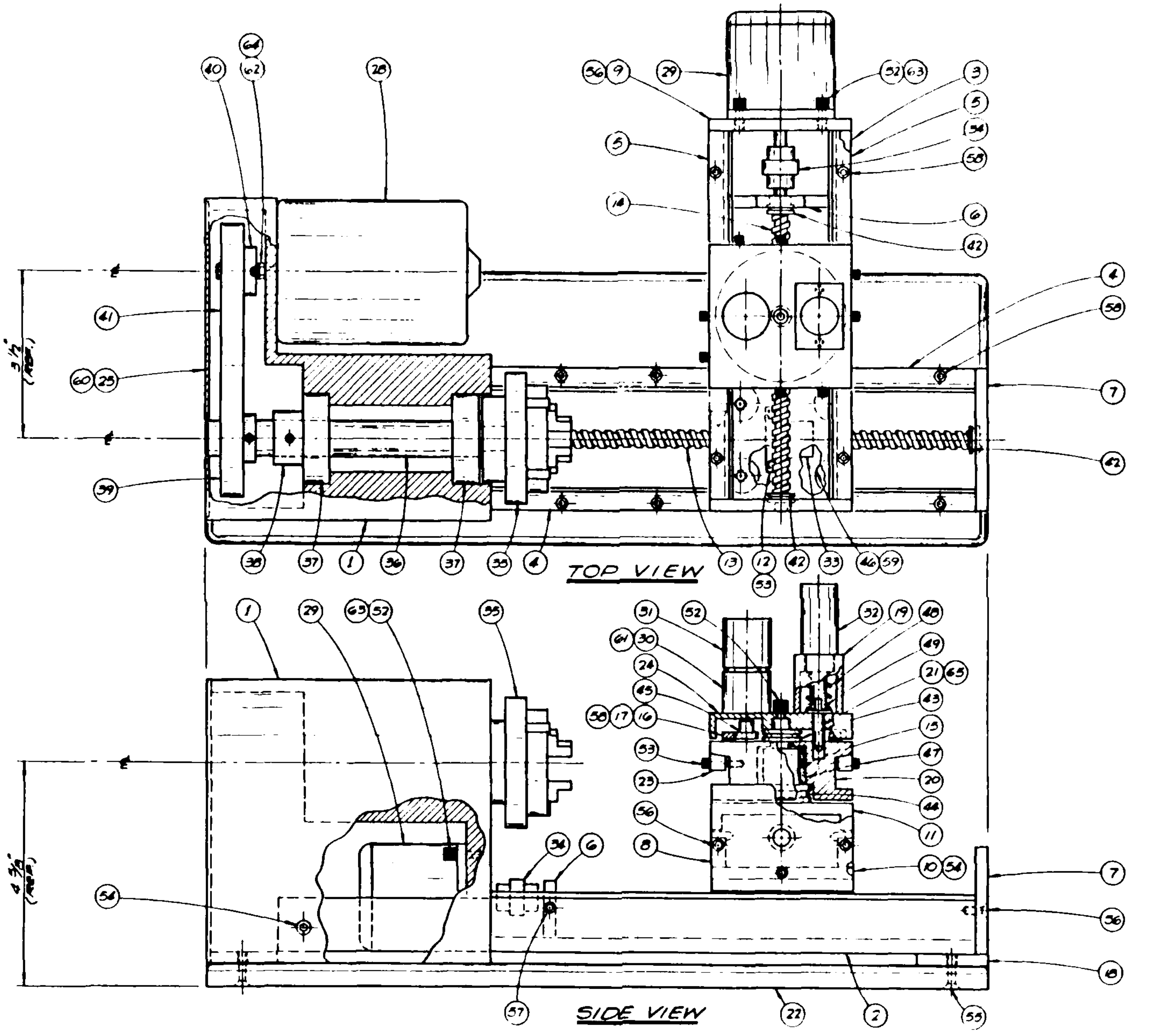
[illegible] 2, 1983 CAE-CAM DEPT.	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	LATHE	DETAIL ITEM 2 & 3		FORREST BLAIR	0035



NOTES
1. WORK THIS DWG WITH BILL OF MATERIALS M0033 AND DWG. NO. 0033.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".

DETAIL ITEM (1) (ALUMINUM)
FULL SCALE

AUGUST 2, 1982 CAD-CAM DEPT.	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	LATHE	DETAIL ITEM 1		FORREST BLAIR	0034



NOTES
1 ALL ITEMS MARKED THUS ○ ARE FOUND ON BILL OF MATERIALS M0033.
2 SPOT WELD ITEM 15 TO ITEM 11 AFTER ASSEMBLY.

AUGUST 2 1982 CAE-CAM DEPT.	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	LATHE	ASSEMBLY	FORREST BLAIR	0033

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0033	Sheet 9 of
Prepared by FORREST BLAIR	Date 9-16-32		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title LATHE			

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
60	0033	Screw - Flathead, Hex Socket,	3	C. Steel	
		#4-40 UNC x ¼" long			
61	0033	Screw - Flathead, Hex Socket,	3	C. Steel	
		Metric M2, Length as required			
62	0033	Nut - Hex, #8-32	2	C. Steel	
63	0033	Washer - Lock, #10	8	C. Steel	
64	0033	Washer - Lock, #8	2	C. Steel	
65	0033	Washer - As Required	1	C. Steel	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0033	Sheet 6 of
Prepared by FORREST BLAIR	Date 9-16-82		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title LATHE			

REVISIONS NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
45	0033	Gear - Spur, 4½° pressure angle,	1	Mfg. Std.	
		32 Pitch, .438" P.D., #1M2-N32014		Standard Drive Products	
46	0033	Guide Wheel - Dualvee, size 1,	8	Mfg. Std.	
		W1X, with Adapter Bushing BX1		Bishop-Wisecarver	
47	0033	Bearing - Plain Bushing, 1" O.D.,	1	Mfg. Std.	
		3/4" I.D., #B1216-6		Boston	
48	0033	Spring - .954" height, #20	1	Mfg. Std.	
				Century Spring	
49	0033	Pin - 3/32" ⌀ x 5/16" long	1	C. Steel	
50		Not Used			
51		Not Used			
52	0033	Cap Screw - Hex Socket,	9	C. Steel	
		#10-32UNF x ½" long			

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BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0033	Sheet 7 of
Prepared by FORREST BLAIR	Date 9-16-82		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title LATHE			

REVISIONS NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
53	0033	Cap Screw - Hex Socket, #8-36 UNF	10	C. Steel	
		x 5/8" long			
54	0033	Screw - Flathead, Hex Socket,	8	C. Steel	
		#10-32 UNF x ½" long			
55	0033	Screw - Flathead, Hex Socket,	4	C. Steel	
		#10-32 UNF x 1" long			
56	0033	Screw - Flathead, Hex Socket,	9	C. Steel	
		#8-36 UNF x 5/8" long			
57	0033	Screw - Flathead, Hex Socket	6	C. Steel	
		#8-36 UNF x 3/4" long			
58	0033	Screw - Flathead, Hex Socket,	22	C. Steel	
		#8-36 UNF x 3/8" long			
59	0033	Screw - Flathead, Hex Socket,	9	C. Steel	
		#6-40 UNF x 7/8" long			

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BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY		Project No	Drawing No M0033	Sheet 4 of
Prepared by FORREST BLAIR	Date 8-16-82	REVISIONS NO.	DESCRIPTION	DATE
Approved by	Date			
Project Engineer	Date			
Project Name CAD-CAM				
Drawing Title LATHE				

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED		DATE
31	0033	Micromotor - #3P41MB3206	1	Mfg. Std.	
				Standard Drive Products	
32	0033	Solenoid - 3/4" tubular pull,	1	Mfg. Std.	
		Series 10, #186175-034		Ledex	
33	0033	Ball Nut - 3/3" nom.,	2	Mfg. Std.	
		RN-0375-0125		Raceaway	
34	0033	Coupling - Wafer Spring, ¼" Bore,	2	Mfg. Std.	
		C020-14		Winfred Berg	
35	0033	Chuck - 3 Jaw Universal,	1	Mfg. Std.	
		No. 3001, ML-1		Toyo	
36	0033	Shaft - Chuck Drive,	1	Mfg. Std.	
		ML-1 Replacement Shaft		Toyo	
37	0033	Bearing - Drive Shaft,	2	Mfg. Std.	
		ML-1 Replacement Bearing (1 ea. end)		Toyo	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY		Project No	Drawing No M0033	Sheet 5 of
Prepared by FORREST BLAIR	Date 8-16-82	REVISIONS NO.	DESCRIPTION	DATE
Approved by	Date			
Project Engineer	Date			
Project Name CAD-CAM				
Drawing Title LATHE				

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
38	0033	Shaft Clamp Nut -	1	Mfg. Std.	
		ML-1 Replacement Nut		Toyo	
39	0033	Pulley - 3/3" Pitch, #37TP4-21,	1	Mfg. Std.	
		Bore to 11/16" dia.		Winfred Berg	
40	0033	Pulley - 3/8" Pitch, #37TP4-16,	1	Mfg. Std.	
		Bore to 5/16" dia.		Winfred Berg	
41	0033	Belt - Timing, 3/8" Pitch,	1	Mfg. Std.	
		#37TB-40, 15" Pitch Length		Winfred Berg	
42	0033	Bearing - Thrust, ¼" Bore,	4	Mfg. Std.	
		#B5-3-SS		Winfred Berg	
43	0033	Bearing - Thrust , 3/3" Bore,	1	Mfg. Std.	
		#B5-5-SS		Winfred Berg	
44	0033	Bearing - Thrust, 3/4" Bore,	1	Mfg. Std.	
		#B5-8-SS		Winfred Berg	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0033	Sheet 2 of
Prepared by FORREST BLAIR	Date 3-16-32	REVISIONS	
Approved by	Date	NO. DESCRIPTION	DATE
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title LATHE			

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
11	0036	Upper Roller Plate	1	Aluminum	
12	0036	Ball Nut Plate	2	Aluminum	
13	0037	Lower Screw	1	See Detail	
14	0037	Upper Screw	1	See Detail	
15	0037	Turret Shaft	1	C. Steel	
16	0037	Turret Gear	1	See Detail	
17	0037	Turret Gear Spacer	1	Nylon	
18	0037	Base Plate Spacer	1	Aluminum	
19	0037	Solenoid Block	1	Aluminum	
20	0037	Turret	1	Aluminum	
21	0037	Turret Stop Pin	1	Aluminum	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. M0033	Sheet 3 of
Prepared by FORREST BLAIR	Date 8-16-82	REVISIONS	
Approved by	Date	NO. DESCRIPTION	DATE
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title LATHE			

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
22	0033	Base Plate	1	Pine	
23	0033	Tool Holder	4	Aluminum	
24	0033	Turret Cap	1	Aluminum	
25	0033	Cover Plate	1	Aluminum	
26		Not Used			
27		Not Used			
28	0033	Motor - Universal AC-DC, 1/5 H.P. #3V2-010K	1	Mfg. Std. Standard Drive Products	
29	0033	Motor - DC Stepping, Slo-syn. #M061-FC02	2	Mfg. Std. Superior Electric	
30	0033	Gearhead - 320:1 Ratio.	1	Mfg. Std. Standard Drive Products	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BRIGHAM YOUNG UNIVERSITY

CAD-CAM DEPT.

BILL OF MATERIALS

PROJECT LATHE (M0033)

DRAWING NO.	DESCRIPTION
0033	ASSEMBLY
0034	DETAIL ITEM 1
0035	DETAIL ITEM 2 & 3
0036	DETAIL ITEM 4, 5, 6, 7, 9, 9, 10, 11, & 12
0037	DETAIL ITEM 13, 14, 15, 16, 17, 13, 19, 20, & 21
0033	DETAIL ITEM 22, 23, 24, & 25

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No M0033	Sheet 1 of

Prepared by: FORREST BLAIR — Date: 3-16-32

Approved by: — Date:

Project Engineer: — Date:

Project Name: CAD-CAM

Drawing Title: LATHE

REVISIONS		
NO	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED			MATERIAL	DATE
	0033	Lathe Assembly	1	*			
1	0034	Drive Housing		1		Aluminum	
2	0035	Bottom Slide		1		Aluminum	
3	0035	Top Slide		1		Aluminum	
4	0036	Bottom Slide Rail		2		See Detail	
5	0036	Top Slide Rail		2		See Detail	
6	0036	Screw Support		2		Aluminum	
7	0036	Slide End Cap		1		Aluminum	
9	0036	Slide End Cap		1		Aluminum	
9	0036	Slide Motor Mount		1		Aluminum	
10	0036	Lower Roller Plate		1		Aluminum	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

APPENDIX D

Detailed Design of Computer Controlled Lathe

ITEM 42 - SAME AS LARGE MILL

ITEM 43 - SAME AS LARGE MILL

ITEM 44 - SAME AS LARGE MILL

ITEM 45 - SAME AS LARGE MILL

ITEM 46 - SAME AS LARGE MILL
(2 REQUIRED INCLUDES ONE NEEDED WITH ITEM 20)

ITEM 47 - NOT NEEDED

ITEM 48 - SAME AS LARGE MILL EXCEPT ONLY 4 REQUIRED

ITEM 49 - SAME AS LARGE MILL

ITEM 50 - SAME AS LARGE MILL EXCEPT ONLY 1 REQUIRED

ITEM 51 - SAME AS LARGE MILL

ITEM 52 - SAME AS LARGE MILL

ITEM 53 - NOT NEEDED

ITEM 54 - NOT NEEDED

ITEM 25 - NOT NEEDED

ITEM 26 - SAME AS LARGE MILL

ITEM 27 - SAME AS LARGE MILL

PURCHASE PARTS

ITEM 28 - SAME AS LARGE MILL

ITEM 29 - SAME AS LARGE MILL

ITEM 30 - SAME AS LARGE MILL EXCEPT
USE ML 1912 INSTEAD OF ML 1851

ITEM 31 - SAME AS LARGE MILL EXCEPT
ORDER 24GCF-200-E, 200 PITCHES,
26.180" CIRC.

ITEM 32 - SAME AS LARGE MILL EXCEPT
ORDER 16GCF-4FT., 225 PITCHES

ITEM 33 - NOT NEEDED

ITEM 34 - NOT NEEDED

ITEM 35 - NOT NEEDED

ITEM 36 - NOT NEEDED

ITEM 37 - SAME AS LARGE MILL

ITEM 38 - SAME AS LARGE MILL

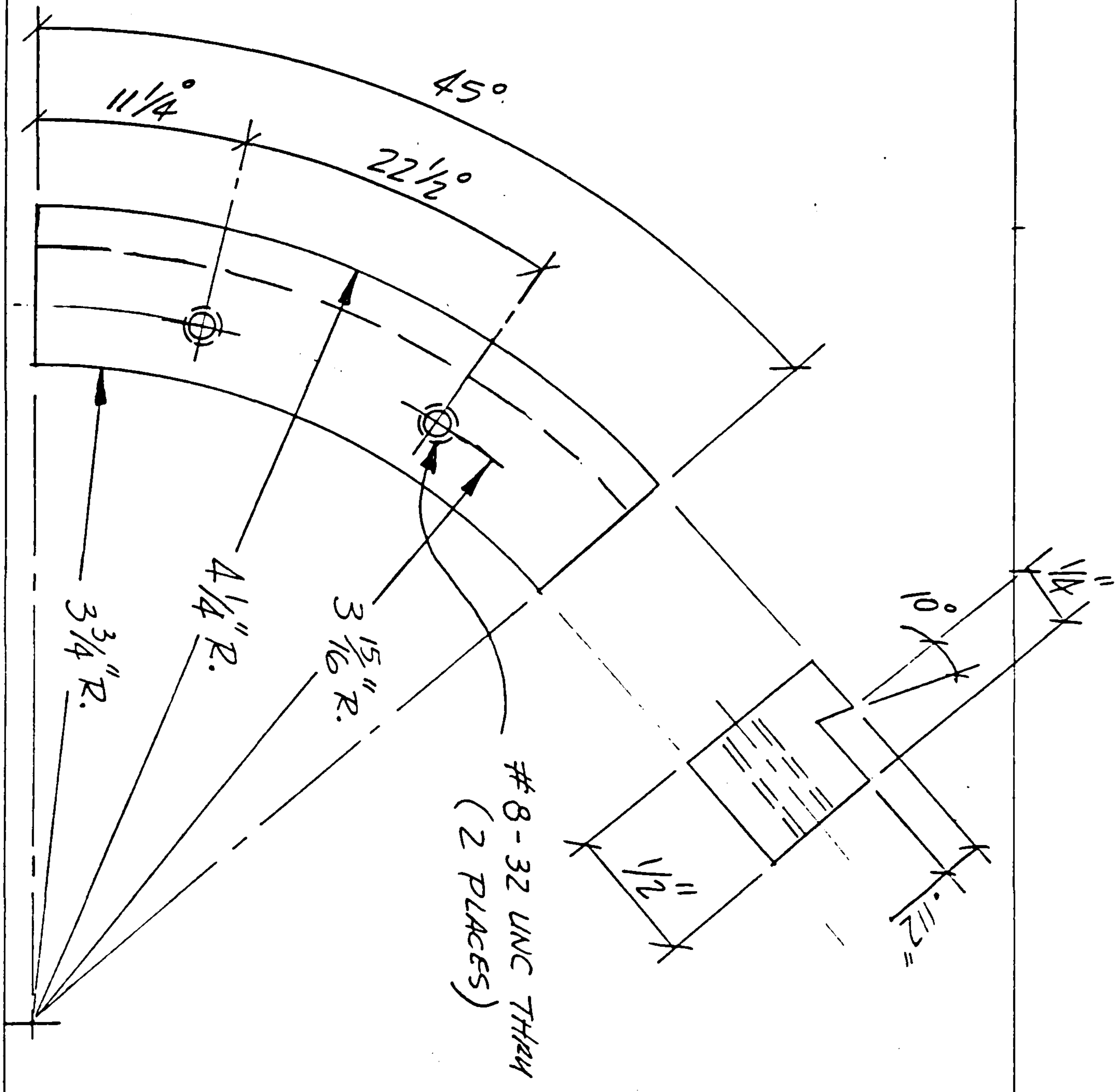
ITEM 39 - SAME AS LARGE MILL
(4 REQUIRED WHICH INCLUDES THE TWO
NEEDED FOR ITEM 20)

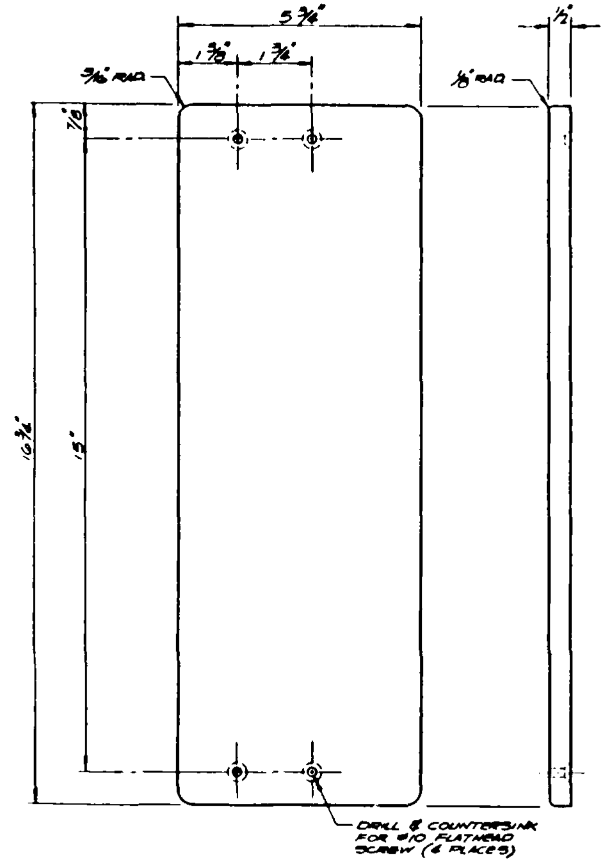
ITEM 40 - SAME AS LARGE MILL

ITEM 41 - WORM GEAR, 24 PITCH, 4" P.D.
STOCK DRIVE PRODUCTS # 1866-N24096
(REMOVE HUB AND DRILL TO MATCH

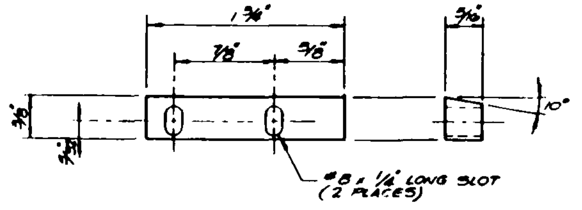
ITEM 24 | TURRET CHAIN CLAMP

8 REQUIRED (ALUMINUM)

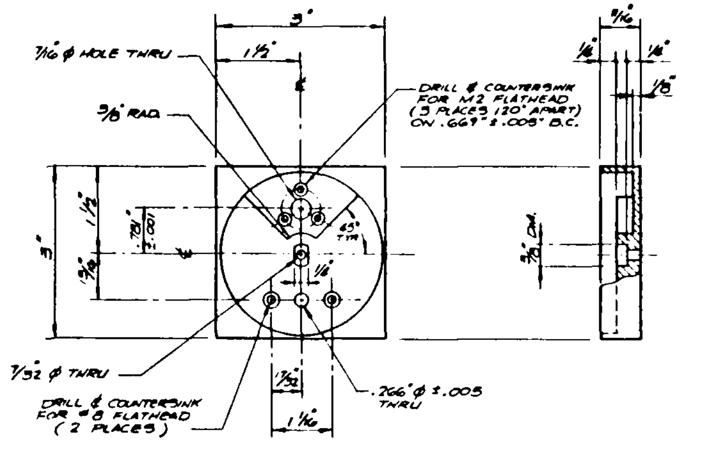




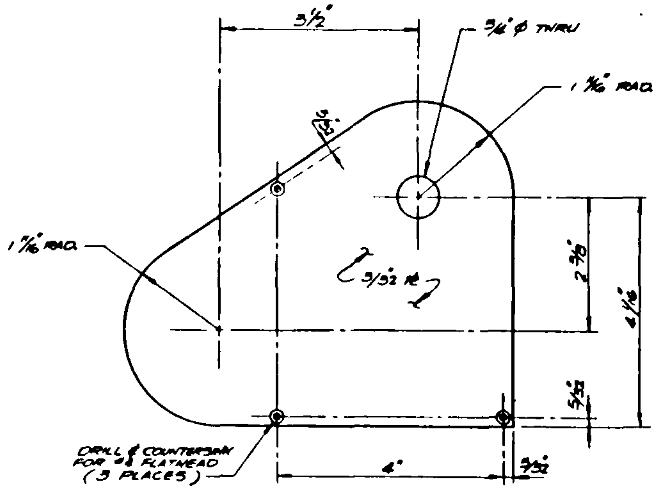
DETAIL ITEM (22) (PINE)
SCALE: 3/4



DETAIL ITEM (23) (ALUMINUM)
SCALE: DOUBLE



DETAIL ITEM (24) (ALUMINUM)
FULL SCALE



DETAIL ITEM (25) (ALUMINUM)
FULL SCALE

NOTES
1. WORK THIS DWG. WITH BILL OF MATERIALS M0033 AND DRAWING NO. 0033.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".

AUGUST 2 1982
CAD - CAM DEPT

BRIGHAM YOUNG UNIVERSITY
PROVO UTAH 84602

LATHE

DETAIL ITEM 22, 23, 24 & 25

FORREST BLAIR

0038

APPENDIX E

Detailed Designs for Miniature Industrial Robot Manipulator

BRIGHAM YOUNG UNIVERSITY

CAD-CAM DEPT.

BILL OF MATERIALS

PROJECT ROBOT (0020)

DRAWING NO.	DESCRIPTION
0020	PATH GENERATION
0021	ASSEMBLY
0022	DETAIL ITEM 1 & 2
0023	DETAIL ITEM 3, 4, 5, & 6
0024	DETAIL ITEM 7, 8, 9, & 10
0025	DETAIL ITEM 11 & 12
0026	DETAIL ITEM 13, 14, 15, 16, 17, 18, & 19
0027	DETAIL ITEM 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 & 30
0028	DETAIL ITEM 31
0029	DETAIL ITEM 32

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. 0010	Sheet 1 of
Prepared by FORREST BLAIR	Date 4-26-82		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title ROBOT			

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED			MATERIAL	DATE
	0021	Robot Assembly	1	*			
1	0022	Base		1		C. Steel	
2	0022	Base Clamp Plate		1		C. Steel	
3	0023	Pivot Base		1		C. Steel	
4	0023	Pitch Worm Gear		1		See Detail	
5	0023	Slide Motor Adj. Plate		1		Aluminum	
6	0023	Pivot Motor Adj. Plate		1		Aluminum	
7	0024	Slide Rail		2		See Detail	
8	0024	Screw Support		1		C. Steel	
9	0024	Ball Nut Attachment		1		C. Steel	
10	0024	Pitch Bracket		1		C. Steel	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No 0010	Sheet 2 of

Prepared by: FORREST BLAIR — Date: 4-26-82
Approved by: — Date:
Project Engineer: — Date:
Project Name: CAD-CAM
Drawing Title: ROBOT

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
11	0025	Slide Motor Support	1	C. Steel	
12	0025	Slide Shaft Support	1	C. Steel	
13	0026	Pitch Motor Support	1	C. Steel	
14	0026	Upper Slide Rail	1	Aluminum	
15	0026	Pitch Preload Plate	1	C. Steel	
16	0026	Slide Shaft Preload Plate	2	Aluminum	
17	0026	Slide Shaft Bearing Cover	2	Aluminum	
18	0026	Slide Thrust Washer Cover	2	Aluminum	
19	0026	Lower Slide Rail	1	Aluminum	
20	0027	Slide Shaft	2	C. Steel	
21	0027	Pitch Drive Shaft	1	C. Steel	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. 0010	Sheet 3 of

Prepared by: FORREST BLAIR — Date: 4-26-82
Approved by: — Date:
Project Engineer: — Date:
Project Name: CAD-CAM
Drawing Title: ROBOT

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
22	0027	Slide Drive Screw	1	See Detail	
23	0027	Pitch Shaft	1	C. Steel	
24	0027	End Eff. Pitch Shaft	2	C. Steel	
25	0027	Pivot Shaft	1	C. Steel	
26	0027	End Eff. Shaft Support	1	C. Steel	
27	0027	End Eff. Bracket	1	C. Steel	
28	0027	End Eff. Support	1	C. Steel	
29	0027	Pivot Shaft Nut	1	C. Steel	
30	0027	Friction Pad	4	Bronze	
31	0028	External Cover	1	Acrylic or Equal	
32	0029	Arm Cover	1	Acrylic	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No 10010	Sheet 4 of
Prepared by FORREST BLAIR	Date 4-26-82		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title ROBOT			

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
33		Not used			
34	0021	Guide Wheel - Dualvee, Size 1,	4	Mfg. Std. Bishop-Wisecarver	
		W1X, with Adapter Bushing BX1			
35	0021	Motor - DC Stepping Slo-Syn	1	Mfg. Std. Superior Electric	
		#M091-FC03			
36	0021	Motor - DC Stepping Slo-Syn,	1	Mfg. Std. Superior Electric	
		#M063-FC06			
37	0021	Motor - DC St ping Slo-Syn,	3	Mfg. Std. Superior Electric	
		#M061-FC02			
38	0021	Gear - Worm, Single Thread, 24	2	Mfg. Std. Winfred Berg	
		Pitch, 3/8" Bore, 2.033 P.D.,			
		#24B35-350			
39	0021	Worm - Single Thread, 24 Pitch,	2	Mfg. Std. Winfred Berg	
		½" Bore, ¾" P.D., #1245-4S			

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No 10010	Sheet 5 of
Prepared by FORREST BLAIR	Date 4-26-82		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title ROBOT			

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIAL	DATE
40	0021	Gear - Bevel, 24 Pitch, #124F-2,	1½sets	Mfg. Std. Winfred Berg	
		1 each 1" P.D. and 2 each 2" P.D.			
41	0021	Worm - Type 1W, LW16-1H, ½" Bore,	1	Mfg. Std. Browning	
		16 Pitch, 1.125 P.D.			
42	0021	Gear - Sprocket, 32 Pitch, ¼" Bore	2	Mfg. Std. Winfred Berg	
		3/4" P.D., GG33S23-24			
43	0021	Chain - Gear Drive, 32 Pitch,	1	Mfg. Std. Winfred Ber-	
		32GCF-75-E, 7.365" circ.			
44	0021	Gear - Sprocket, 16 Pitch, 3/8"	1	Mfg. Std. Winfred Berg	
		Bore, 18 Teeth, 1.1250 P.D.,			
		GG17S36-18			
45	0021	Chain - Gear Drive, 16 Pitch,	1	Mfg. Std. Winfred Ber-	
		16GCF-170-E, 170 Pitches,			
		33.405" circ.			

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BILL OF MATERIALS

BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. 10010	Sheet 6 of
Prepared by FORREST BLAIR	Date 4-26-82		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title ROBOT			

REVISIONS

NO.	DESCRIPTION	DATE

ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIALS	DATE
46	0021	Bushing - 3/8" Bore, ½" Long,	7	Mfg. Std. Winfred Berg	
		B6-41			
47	0021	Bushing - 3/8" Bore, 3/8" Long,	1	Mfg. Std. Winfred Berg	
		B7-42			
48	0021	Bushing - Plain Cylindrical,	2	Mfg. Std. Boston Gear	
		1" nom., 1 3/8" Long, #35066			
		B1620-7			
49	0021	Bushing - Plain Cylindrical,	2	Mfg. Std. Boston Gear	
		3/4" nom., 7/8" Long,			
		#34976 B1216-7			
50	0021	Bushing - Washer, Thrust, 3/4"	2	Mfg. Std. Boston Gear	
		nom., 69222 T3-1212			
51	0021	Bearing - ½" Bore, B1-44	2	Mfg. Std. Winfred Berg	
52	0021	Bearing - ½" Bore, B1-22	2	Mfg. Std. Winfred Berg	
53	0021	Washer - Thrust, ½" Bore, B5-6-SS	[illegible]	Mfg. Std. Winfred Berg	

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT.

BILL OF MATERIALS

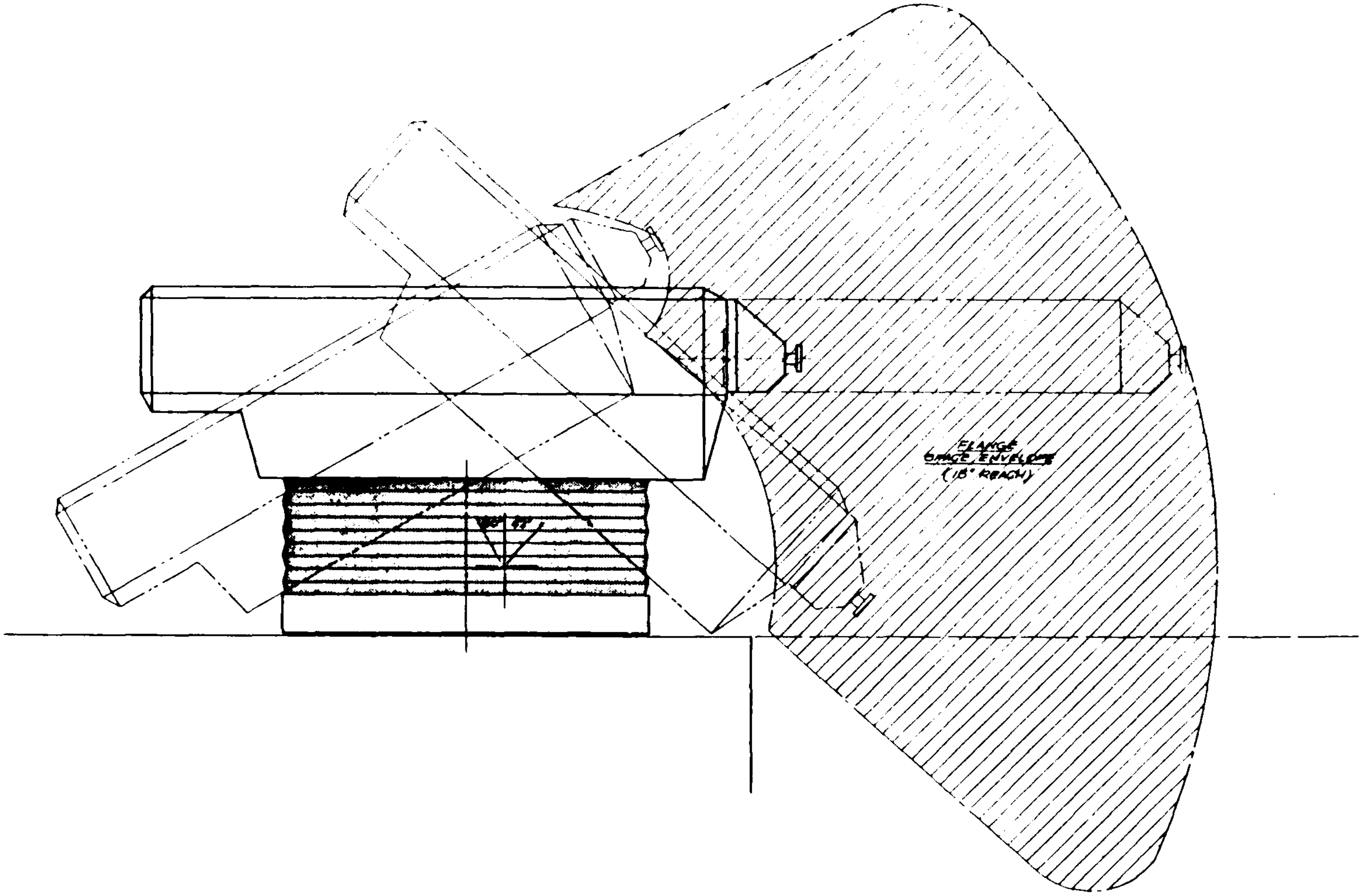
BRIGHAM YOUNG UNIVERSITY	Project No.	Drawing No. 10010	Sheet 7 of
Prepared by FORREST BLAIR	Date 4-26-82		
Approved by	Date		
Project Engineer	Date		
Project Name CAD-CAM			
Drawing Title ROBOT			

REVISIONS

NO.	DESCRIPTION	DATE

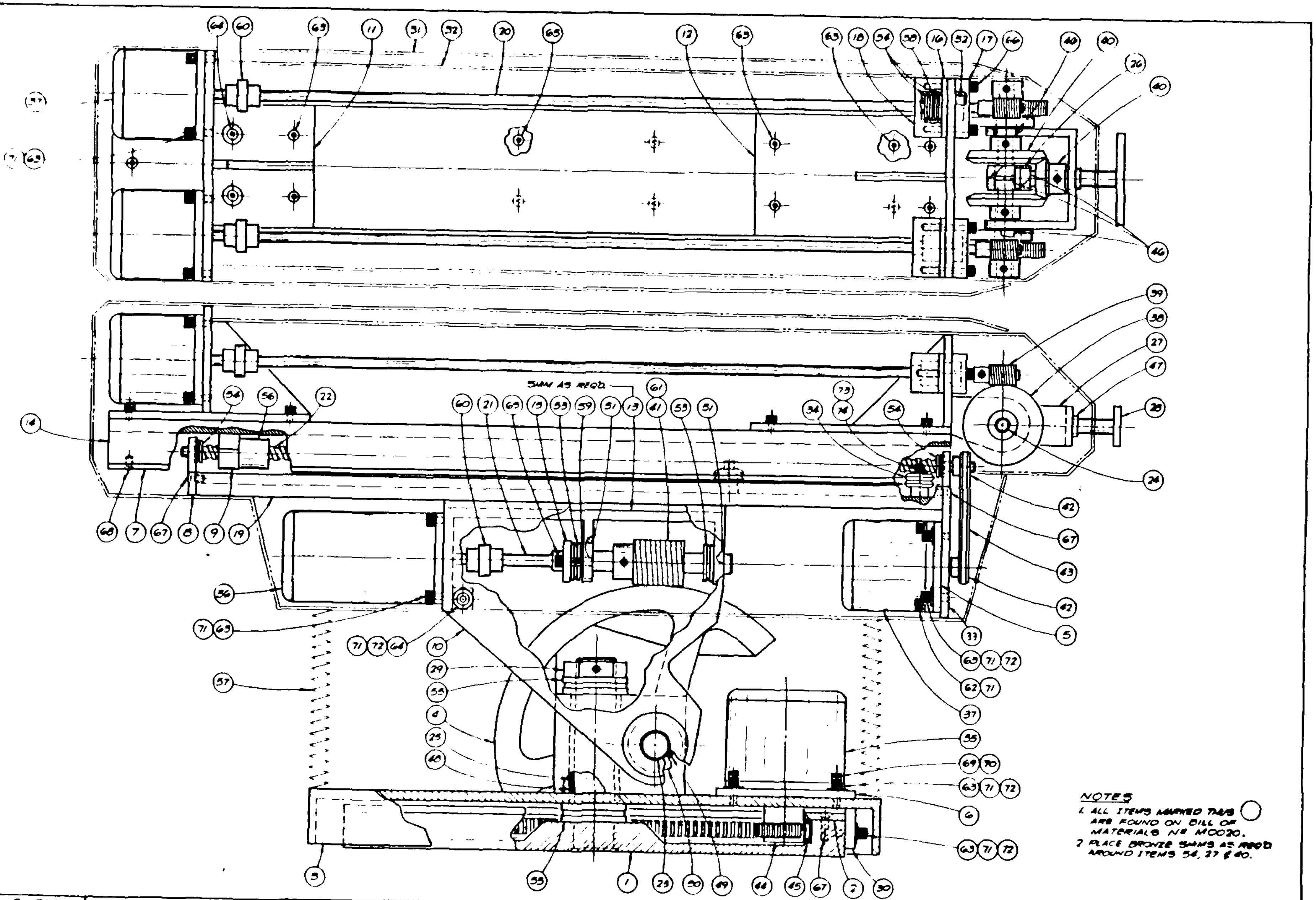
ITEM	DWG. NUMBER	PART NAME (Material Description)	UNITS REQUIRED	MATERIALS	DATE
54	0021	Washer - Thrust, ½" Bore, B5-8-SS	6	Mfg. Std. Winfred Berg	
55	0021	Washer - Thrust, 1" nom., B5-10-SS	2	Mfg. Std. Winfred Berg	
56	0021	Ball Nut - 3/8" nom., RN-0375-0125	1	Mfg. Std. Raceaway	
57	0021	Bellows - 13½" x 4" I.D., 4½" nom.	1	As Required	
		height, must expand to 10".			
58	0021	Retainer Ring - ¼" nom., Q1-25	2	Mfg. Std. Winfred Berg	
59	0021	Retainer Ring - ½" nom., Q1-50	1	Winfred Berg Or Equal	
60	0021	Coupling - Wafer Spring, ½" Bore,	1	Mfg. Std. Winfred Berg	
		C020-14			
61	0021	Key - 1/8" Square, 1 3/4" Long	1	Key Stock	
62	0021	Cap Screw - Hex Socket,	4	C. Steel	
		#10-32 UNF x 3/8" Long			

DRAFTSMAN PREPARE 1 COPY AND RETAIN ORIGINAL. SEND PHOTOCOPIES TO VENDOR AND FACTORY PURCHASING AGENT



SCALE : 1/2" = 1"

MARCH 9, 1982 CAD-CAM DEPT.	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	ROBOT	PATH GENERATION		FORREST BLAIR
					0020



NOTES
1. ALL ITEMS MARKED THUS ○ ARE FOUND ON BILL OF MATERIALS Nº M0020.
2 PLACE BRONZE SHIMS AS REQ'D AROUND ITEMS 54, 27 & 40.

MARCH 19 1982
CAD-CAM DEPT.

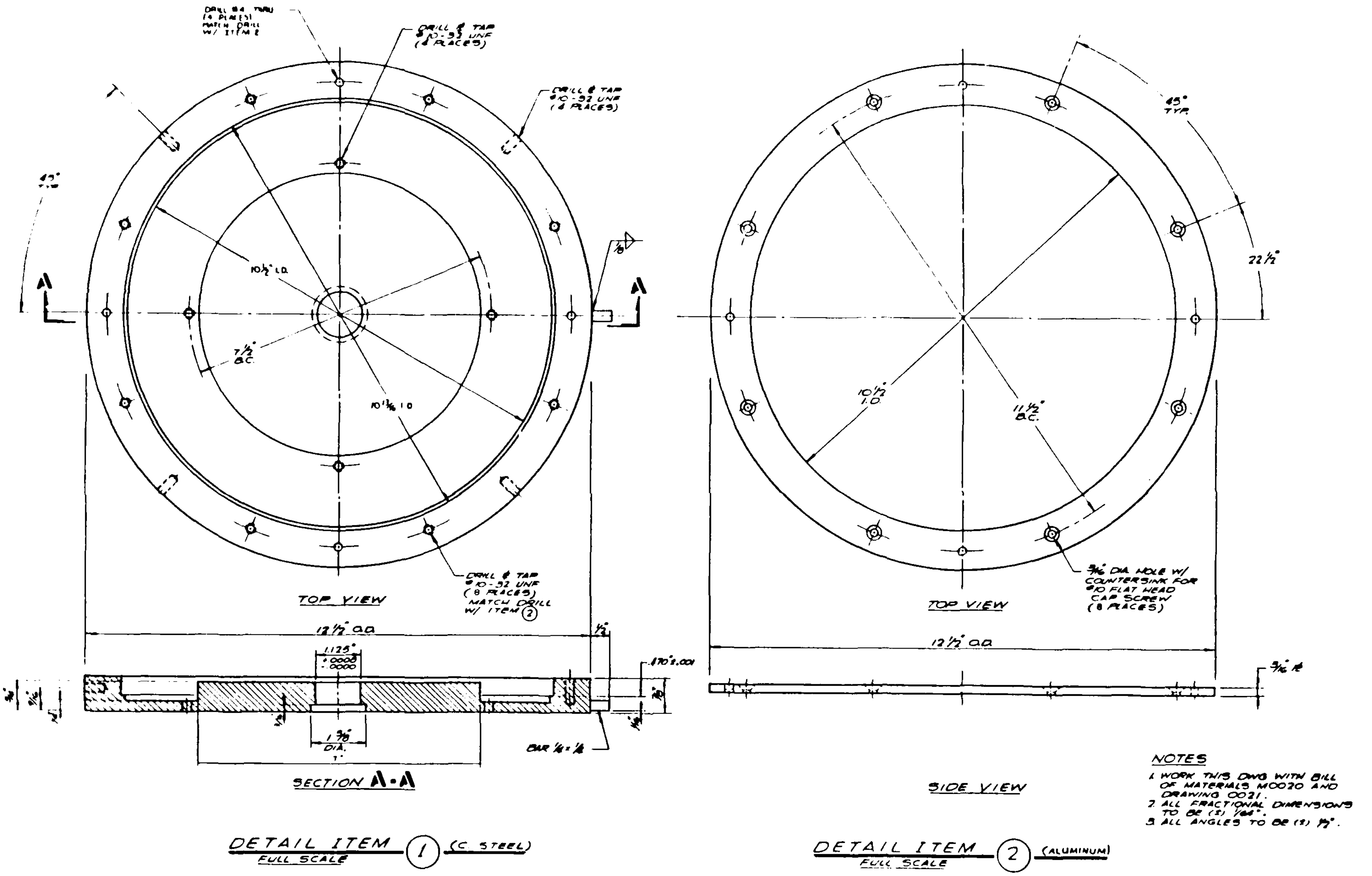
BRIGHAM YOUNG UNIVERSITY
PROVO UTAH 84602

ROBOT

ASSEMBLY

FORREST BLAIR

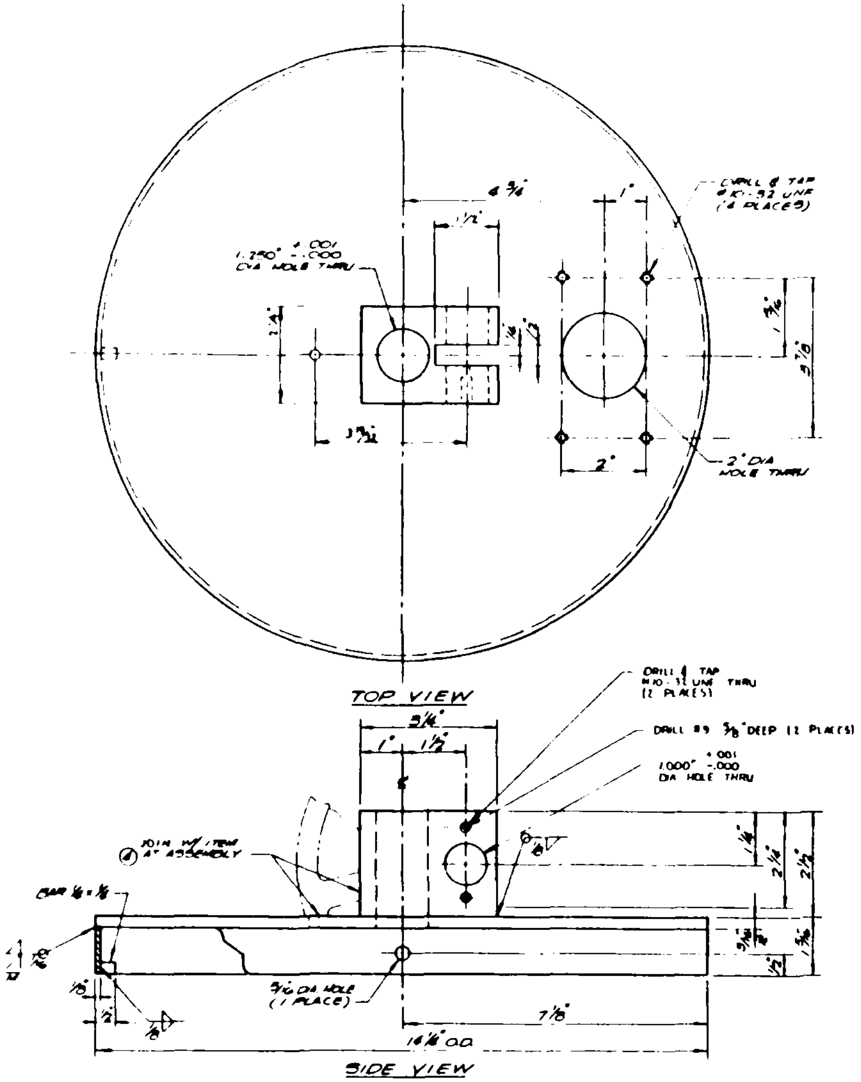
0021



NOTES

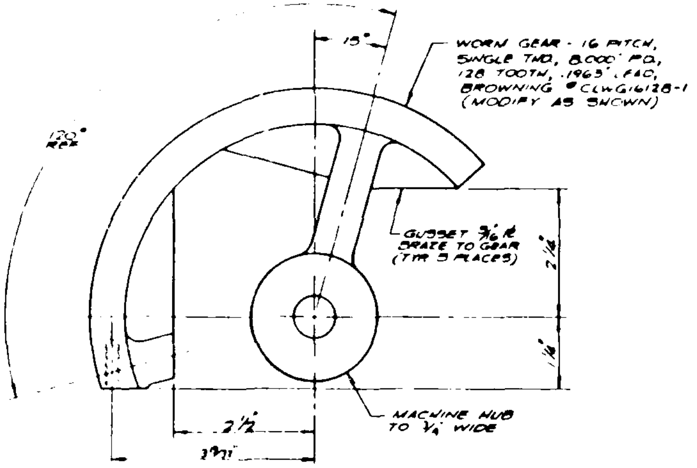
1. WORK THIS DWG WITH BILL OF MATERIALS M0020 AND DRAWING 0021.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".
3. ALL ANGLES TO BE (±) 1/2°.

MARCH 19, 1982 CAD-CAM DEPT.	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	ROBOT	DETAIL ITEM 1 & 2		FORREST BLAIR	0022


4 3/4"
1/2"
1"
DRILL & TAP #10-32 UNF (4 PLACES)
1.250" +.001 -.000 DIA HOLE THRU
2 1/4"
1 3/16"
3 1/8"
3 15/32"
2"
2" DIA HOLE THRU
TOP VIEW
3 1/4"
1"
1 1/2"
DRILL & TAP #10-32 UNF THRU (2 PLACES)
DRILL #9 3/8" DEEP (2 PLACES)
1.000" +.001 -.000 DIA HOLE THRU
1/8
JOIN W/ ITEM 4 AT ASSEMBLY
BAR 1/8 x 1/8
1 1/4"
2 1/4"
2 1/2"
3/16 DIA HOLE (1 PLACE)
7 1/8"
14 1/4" O.D.
1/2
1/8
SIDE VIEW

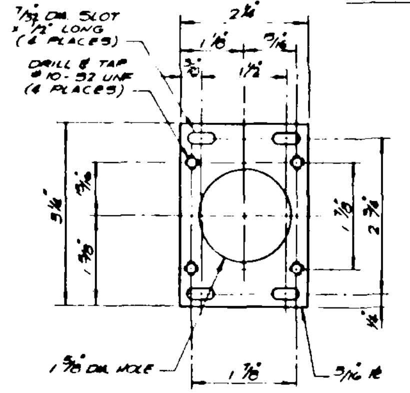
DETAIL ITEM (3) (C. STEEL)

3/4 SCALE


15°
120° REF
WORM GEAR - 16 PITCH, SINGLE THD, 8.000" P.D., 128 TOOTH, .1963" FAC, BROWNING #CLWG16128-1 (MODIFY AS SHOWN)
GUSSET 3/16 PL BRAZE TO GEAR (TYP 3 PLACES)
2 1/4"
1 1/4"
MACHINE HUB TO 3/4 WIDE
2 1/2"
3 9/32"

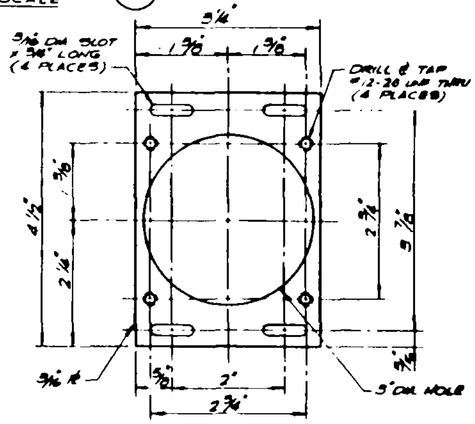
DETAIL ITEM (4)

FULL SCALE



DETAIL ITEM (5) (ALUMINUM)

FULL SCALE


3/16 DIA SLOT x 3/4" LONG (4 PLACES)
3 1/4"
1 5/8"
1 5/8"
DRILL & TAP #12-28 UNF THRU (4 PLACES)
4 1/2"
2 1/4"
2 3/4"
3 7/8"
3/16 PL
2"
2 3/4"
3" DIA HOLE

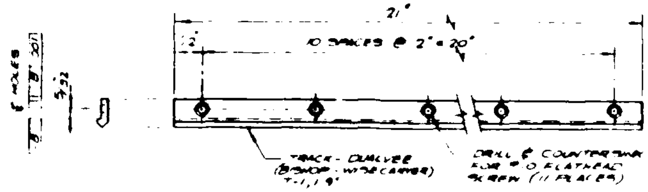
DETAIL ITEM (6) (ALUMINUM)

FULL SCALE

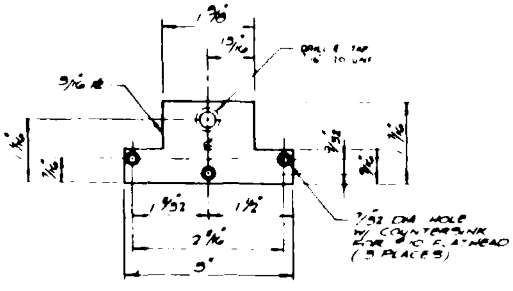
NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS M0020 AND DRAWING 0021.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".

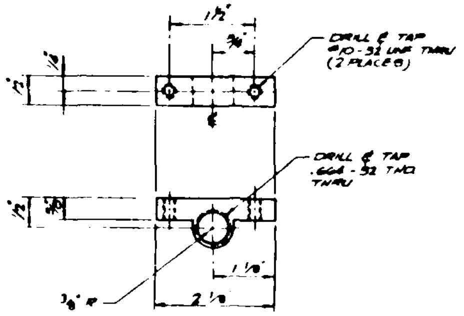
MARCH 9 1982 CAD-CAM DEPT.	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	ROBOT	DETAIL ITEM 3,4,5 & 6	FORREST BLAIR	0023



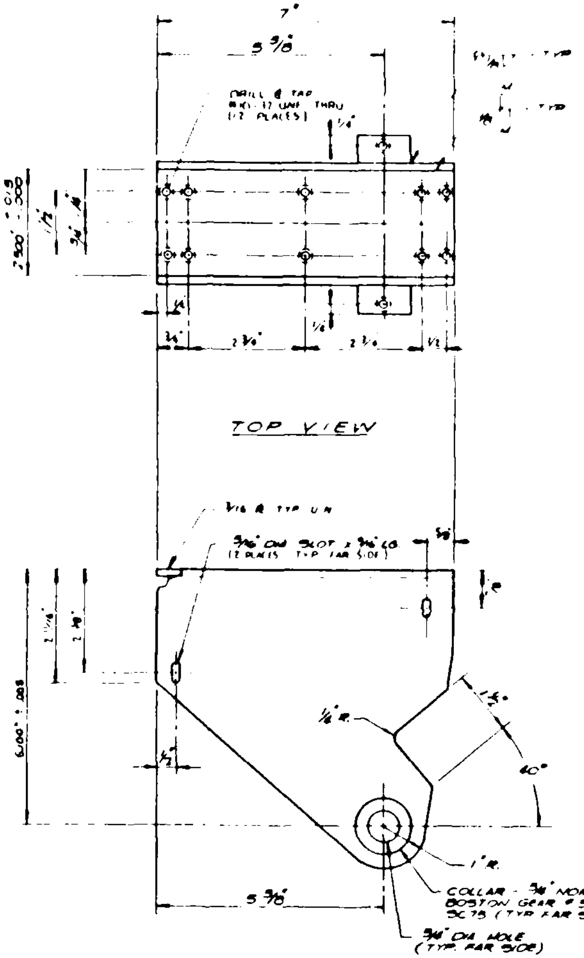
CETAIL ITEM (7)
FULL SCALE



DETAIL ITEM (8) (C. STEEL)
FULL SCALE



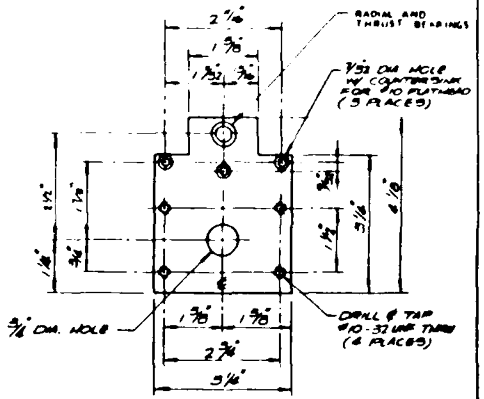
DETAIL ITEM (9) (C. STEEL)
FULL SCALE



TOP VIEW

SIDE VIEW

DETAIL ITEM (10) (C. STEEL)
— 3/4 SCALE



DETAIL ITEM (33) (C. STEEL)
3/4 SCALE

NOTES
1. WORK THIS DWG. WITH BILL OF MATERIALS M0020 AND DRAWING 0021.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".

MARCH 9, 1982
CAD-CAM DEPT.

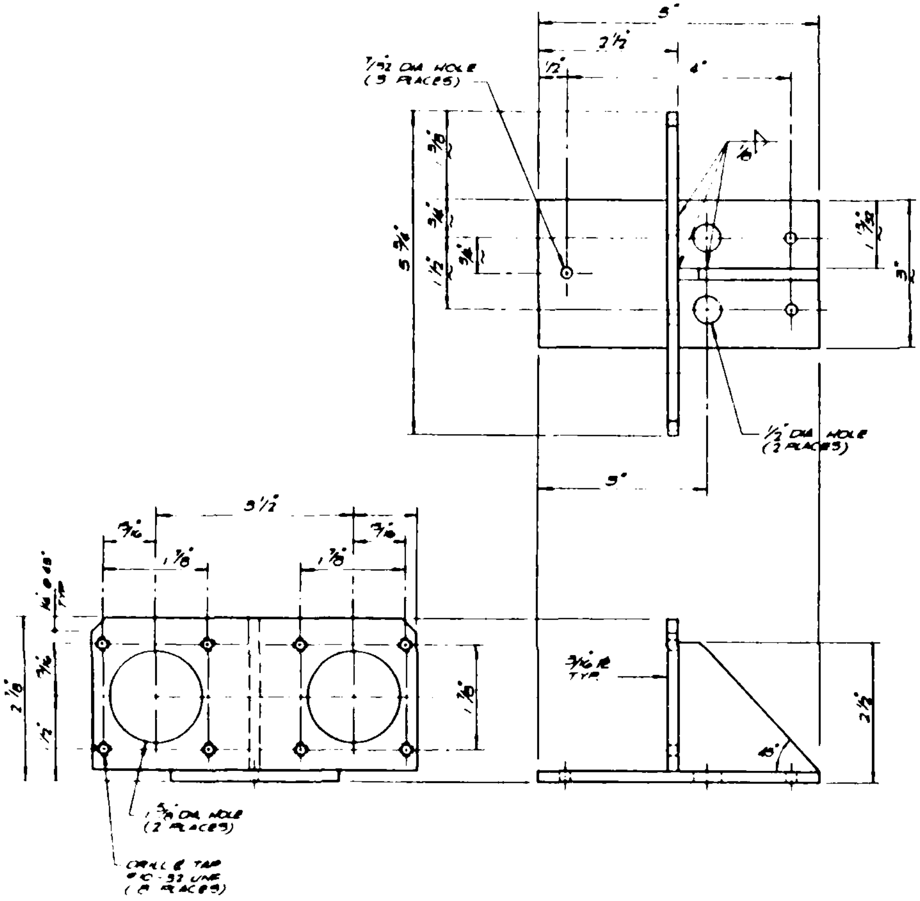
BRIGHAM YOUNG UNIVERSITY
PROVO UTAH 84602

ROBOT

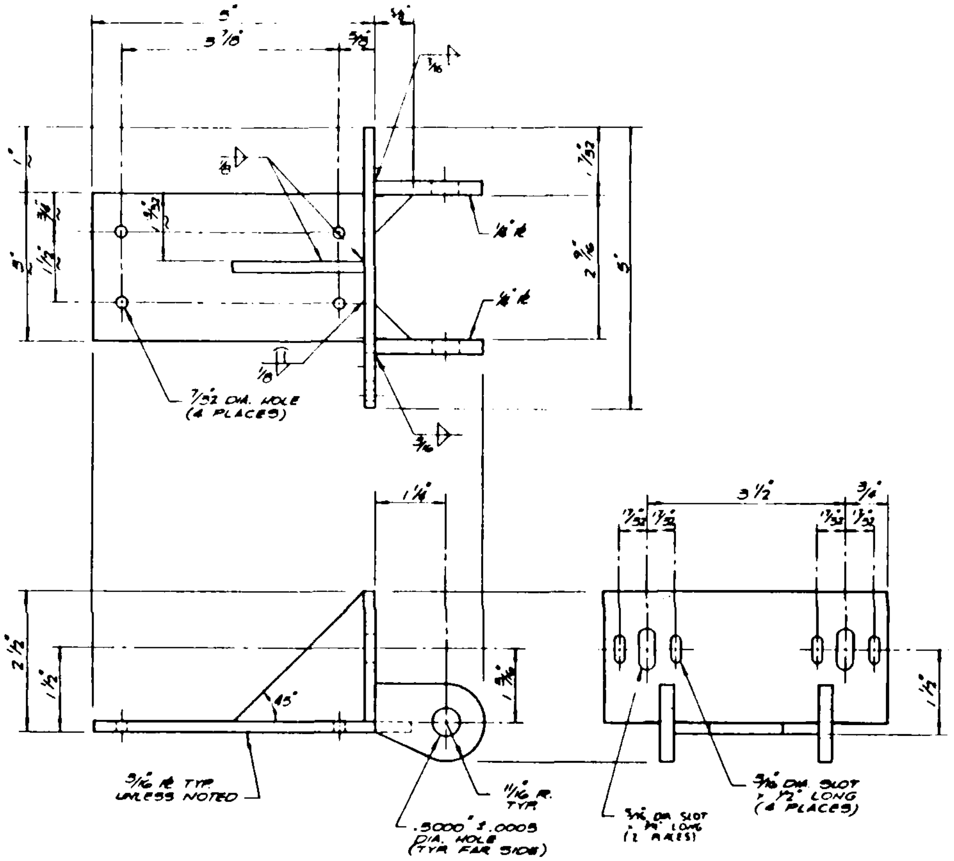
DETAIL ITEM 7,8,9&10

FORREST BLAIR

0024



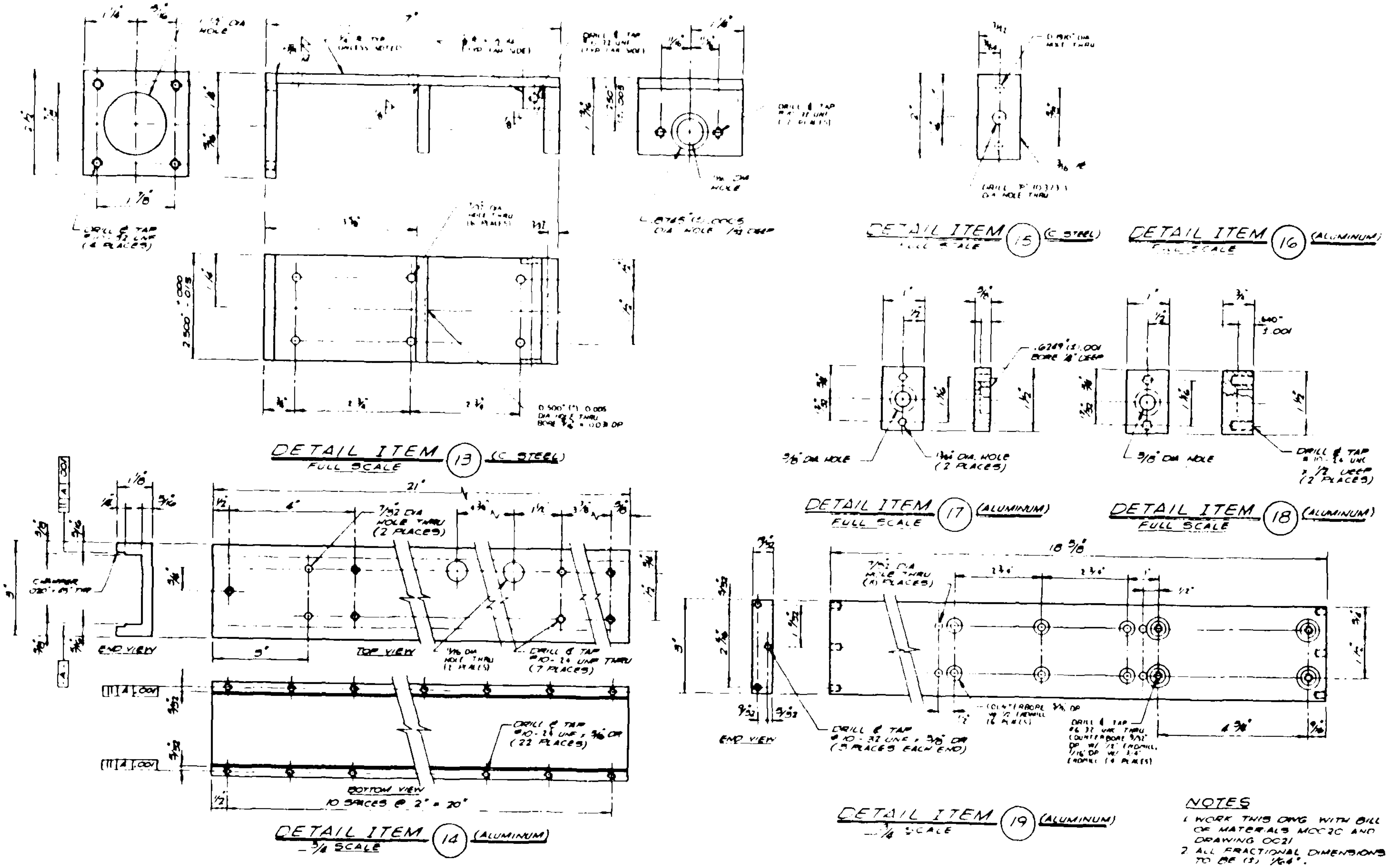
DETAIL ITEM (11) (C STEEL)
FULL SCALE



DETAIL ITEM (12) (C. STEEL)
FULL SCALE

NOTES
1. WORK THIS DWG WITH BILL OF MATERIALS M0020 AND DRAWING 0021.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".

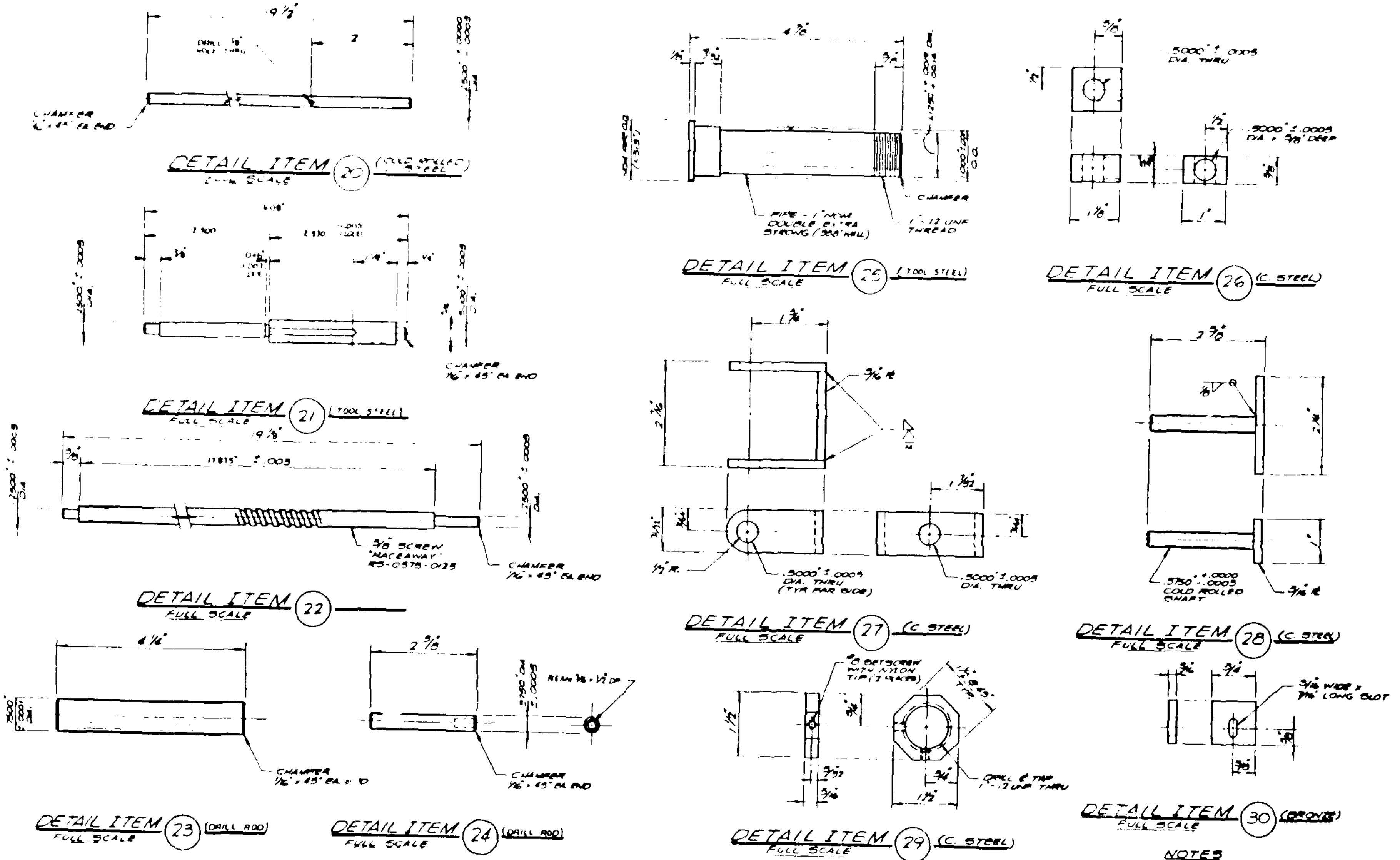
MARCH 9 1982 CAD-CAM DEPT.	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	ROBOT	DETAIL ITEM 11 & 12		FORREST BLAIR	0025


1 1/4"
5/16"
1.12" DIA HOLE
2 1/2"
1 7/8"
DRILL & TAP #10-32 UNF (4 PLACES)
7"
1/4" R TYP UNLESS NOTED
DRILL & TAP #10-32 UNF (TYP FAR SIDE)
1 5/8"
1/32
7/32" DIA HOLE THRU (6 PLACES)
2.500" +.000 -.015
1/4"
2 1/4"
0.500" (+) 0.005 DIA HOLE THRU BORE 1/4" x 0.03 DP
DETAIL ITEM 13 (C STEEL)
FULL SCALE
1 1/8"
11/16"
.250 (±).005
DRILL & TAP #10-32 UNF (2 PLACES)
7/16" DIA HOLE
.8745" (±).0005 DIA HOLE 1/32 DEEP
0.1910" DIA HOLE THRU
3/16 R
DRILL "P" (0.323) DIA HOLE THRU
DETAIL ITEM 15 (C STEEL)
FULL SCALE
DETAIL ITEM 16 (ALUMINUM)
FULL SCALE
1"
1/2"
5/16"
.6249" (±).001 BORE 1/8" DEEP
1 1/2"
3/8" DIA HOLE
13/64" DIA. HOLE (2 PLACES)
3/4"
.640" ±.001
DRILL & TAP #10-24 UNC x 1/2 DEEP (2 PLACES)
DETAIL ITEM 17 (ALUMINUM)
FULL SCALE
DETAIL ITEM 18 (ALUMINUM)
FULL SCALE
1 1/8"
5/16"
3"
CHAMFER .020" x 45° TYP
END VIEW
21"
1/2"
4"
7/32" DIA HOLE THRU (2 PLACES)
3/8"
1 1/2"
5"
TOP VIEW
11/16" DIA HOLE THRU (2 PLACES)
DRILL & TAP #10-24 UNF THRU (7 PLACES)
A
.001
DRILL & TAP #10-24 UNF x 3/8" DP (22 PLACES)
BOTTOM VIEW
10 SPACES @ 2" = 20"
DETAIL ITEM 14 (ALUMINUM)
3/4 SCALE
18 5/8"
7/32" DIA HOLE THRU (8 PLACES)
2 3/4"
1"
1/2"
9/32"
2 7/16"
3"
END VIEW
DRILL & TAP #10-32 UNF x 3/8" DP (3 PLACES EACH END)
COUNTERBORE 3/16 DP W/ 1/2 ENDMILL (6 PLACES)
DRILL & TAP #6-32 UNC THRU COUNTERBORE 9/32" DP W/ 1/2" ENDMILL, 1/16" DP W/ 3/4" ENDMILL (4 PLACES)
4 3/8"
9/16"
DETAIL ITEM 19 (ALUMINUM)
3/4 SCALE

NOTES

1. WORK THIS DWG WITH BILL OF MATERIALS MCC2C AND DRAWING CC21
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".

MARCH 19, 1982 CAE - CAM DEPT	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	ROBOT	DETAIL ITEM 13,14,15,16,17,18 & 19	FORREST BLAIR	CC26


DETAIL ITEM 20 (COLD ROLLED STEEL)
FULL SCALE
9 1/2"
2
DRILL 1/8" HOLE THRU
CHAMFER 1/16" x 45° EA END
.2500" ± .0000 / .0005 DIA
DETAIL ITEM 21 (TOOL STEEL)
FULL SCALE
CHAMFER 1/16" x 45° EA END
DETAIL ITEM 22
FULL SCALE
9 1/8"
11.875" ± .005
3/8 SCREW "RACEWAY" RS-0375-0125
CHAMFER 1/16" x 45° EA END
DETAIL ITEM 23 (DRILL ROD)
FULL SCALE
4 1/8"
CHAMFER 1/16" x 45° EA END
DETAIL ITEM 24 (DRILL ROD)
FULL SCALE
2 3/8"
REAM 1/8 x 1/2 DP
CHAMFER 1/16" x 45° EA END
DETAIL ITEM 25 (TOOL STEEL)
FULL SCALE
4 7/8"
PIPE - 1" NOM DOUBLE EXTRA STRONG (.358 WALL)
CHAMFER
1" - 12 UNF THREAD
DETAIL ITEM 26 (C. STEEL)
FULL SCALE
.5000" ± .0005 DIA THRU
.5000" ± .0005 DIA x 3/8 DEEP
1 1/8"
1"
DETAIL ITEM 27 (C STEEL)
FULL SCALE
1 3/4"
2 7/16"
3/16
1 3/32
1/2 R.
.5000" ± .0005 DIA. THRU (TYP FAR SIDE)
.5000" ± .0005 DIA. THRU
DETAIL ITEM 28 (C. STEEL)
FULL SCALE
2 3/8"
2 1/4"
1"
.3750" + .0000 / - .0005 COLD ROLLED SHAFT
3/16
3/16 WIDE x 7/16 LONG SLOT
DETAIL ITEM 29 (C. STEEL)
FULL SCALE
#8 SETSCREW WITH NYLON TIP (2 PLACES)
1 1/2"
DRILL & TAP 1" - 12 UNF THRU
DETAIL ITEM 30 (BRONZE)
FULL SCALE

NOTES
1. WORK THIS DWG WITH BILL OF MATERIALS M0020 AND DRAWING 0021.
2. ALL FRACTIONAL DIMENSIONS TO BE (±) 1/64".

1982 AC-CAM DEPT.	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	ROBOT	DETAIL ITEM 20 21, 22 23, 24 25, 26, 27, 28 29 & 30	FORREST BLAIR	0027

```
04B8    45 20 3D 20
04BC    24
04BD    52 41 54 45             VERATE: DB      "RATE = $"      ;
04C1    20 3D 20 24
04C5    46 41 43 54             VEFACT: DB      "FACTOR = $"    ;
04C9    4F 52 20 3D
04CD    20 24
04CF    20 48 41 4C             VEHLST: DB      " HALF STEP $"
04D3    46 20 53 54
04D7    45 50 20 24
04DB    20 46 55 4C             VEFLST: DB      " FULL STEP $"
04DF    4C 20 53 54
04E3    45 50 20 24
04E7    43 4C 4F 43             VECWM:  DB      "CLOCKWISE $"
04EB    4B 57 49 53
04EF    45 20 24
04F2    43 4F 55 4E             VECCWM: DB      "COUNTER CLOCKWISE $"
04F6    54 45 52 20
04FA    43 4C 4F 43
04FE    4B 57 49 53
0502    45 20 24
0505    50 55 4C 53             PEQUAL: DB      "PULSES FROM HOME = $"
0509    45 53 20 46
050D    52 4F 4D 20
0511    48 4F 4D 45
0515    20 3D 20 24
                                ;
                                ;
                                ;
                                ;*******************************************************
                                ;*    SEND CHARACTER TO THE CY512
                                ;*
                                ;: THIS ROUTINE SEND THE CHARACTER IN THE 'A' REG
                                ;* TO THE ACTIVE CY 512  MOTOR CONTROLLER
                                ;*******************************************************
                                ;ENTER THIS ROUTINE WITH THE ASCII CHARACTER
                                ;CURRENTLY LOADED IN THE 'A' REGISTER.
                                ;
0519    CD 06A2                 SENDCY: CALL    SAVREG          ;SAVE ACTIVE REGS.
051D    FD 2A 0322                      LD      IY,(CYCTRL)     ;SET THE POINTER TO ACTIVE CY512
0520    FD CB 00 56             SCWAIT: BIT     2,(IY)          ;TEST THE CY512, IS IT READY???
0524    CA 0520                         JP      Z,SCWAIT        ;I'M BUSY, PLEASE WAIT.
0527    E6 7F                           AND     07FH            ;MAKE SURE CHR IS ASCII.
0529    FD 77 04                        LD      (IY+4),A        ;PLACE CHAR IN CY DATA REGISTER
052C    2E 41                           LD      L,41H           ;SET I/O REQUEST BIT
052E    FD 75 00                        LD      (IY),L
0531    FD CB 00 56             SCHDSK: BIT     2,(IY)          ;HANDSHAKE WITH CY512 READY FLAG.
0535    C2 0531                         JP      NZ,SCHDSK       ;WAIT UNTIL CHAR IS TAKEN
0538    2E 40                           LD      L,40H           ;RESET I/O REQUEST BIT.
053A    FD 75 00                        LD      (IY),L          ;...
053D    CD 0689                         CALL    RESTOR          ;RESTORE PROCESSOR REGS.
0540    C9                                      RET             ;EXIT THE SENDCY ROUTINE...
                                ;
                                ;
                                ;***************************************************
                                ;*     GET A CHARACTER FROM THE CY512
```

```
0449    CD 0581         VEDSCT: CALL    PRINT           ;...'CCW' ON THE DISPLAY.
044C    DD CB 05 7E             BIT     7,(IX+5)        ;IS THE 'HALF STEP' BIT SET ?
0450    CA 0466                 JP      Z,VEFS          ;NO, GO PRINT 'FULL STEP' ON DISPLAY.
0453    11 04CF                 LD      DE,VEHLST       ;YES, PRINTOUT 'HALF STEP' ON SCREEN.
0456    CD 0581         VEEXIT: CALL    PRINT           ;.....
0459    CD 05A3                 CALL    CRLF            ;......
045C    CD 06B9                 CALL    RESTOR          ;RESTORE IX REGISTER AND....
045F    C9                              RET             ;...EXIT THIS ROUTINE.
                        ;
0460    11 04E7         VECW:   LD      DE,VECWM        ;PRINTOUT 'CW' ON ....
0463    C3 0449                 JP      VEDSCT          ;..THE SCREEN.
                        ;
0466    11 04DE         VEFS:   LD      DE,VEFLST       ;PRINT 'FULL STEP' ON.....
0469    C3 0456                 JP      VEEXIT          ;..THE SCREEN.
                        ;
046C    06 00           VECTPT: LD      B,0             ;WE WILL OUTPUT 4 CHR'S....
046E    7E              VOLOOP: LD      A,(HL)          ;TRANSFER CHR FROM THE CHR BUFFER...
046F    CD 0519                 CALL    SENDCY          ;SEND TO THE CY512, 'B' WILL COUNT THEM.
0472    23                      INC     HL              ;INC CHR POINTER.
0473    04                      INC     B               ;INCREMENT THE COUNT...
0474    CB 50                   BIT     2,B             ;..AND SEE IF 4 CHR'S SENT YET ?
0476    CA 046E                 JP      Z,VOLOOP        ;NOPE, DO ANOTHER.
0479    C9                              RET             ;.......
                        ;
047A    CD 06A2         VFETCH: CALL    SAVREG          ;SAVE THE 'X' REG.
047D    3E 00                   LD      A,0             ;CLEAR THE BYTE COUNTER.
047F    2A 0497                 LD      HL,(VCOUNT)     ;LOAD THE BYTE COUNT INTO 'HL' REG.
0482    DD 21 0498              LD      IX,NUMBER       ;SET PNTR TO THE DATA BUFFER.
0486    CD 0541         VFLOOP: CALL    GETCY           ;GO GET A DATA BYTE..
0489    DD 73 00                LD      (IX),E          ;..AND STORE IT IN THE DATA BUFFER.
048C    DD 23                   INC     IX              ; INC THE BUFFER POINTER AND...
048E    3C                      INC     A               ;..THE BYTE TRANSFER COUNT...
048F    BD                      CP      L               ;HAVE WE FETCHED ALL THE CHR'S YET ?
0490    C2 0486                 JP      NZ,VFLOOP       ;NO, GO GET ANOTHER CHR.
0493    CD 06B9                 CALL    RESTOR          ;YES, RESTORE 'X' REG AND...
0496    C9                              RET             ;..EXIT
                        ;
0497    00              VCOUNT:         0               ;
                        ;
                        ;  THIS IS THE CY512 DATA BYTE BUFFER.
                        ;
0498    00              NUMBER:         0               ;'N' PULSES COUNT.
0499    00                              0               ;.....
049A    00              SLOPE:          0               ;SLOPE COUNT.
049B    00              RATE:           0               ;RATE COUNT.
049C    00              FACTOR:         0               ;FACTOR COUNT.
049D    00              STATUS:         0               ;STATUS COUNT.
                        ;
049E    56 20 30 0D     VZERO:  DB      "V 0",13        ;THE "V 0" CHR STRING.
04A2    56 20 32 0D     VTWO:   DB      "V 2",13        ;THE "V 2" CHR STRING.
04A6    56 20 33 0D     VTHREE: DB      "V 3",13        ;THE "V 3" CHR STRING.
                        ;
04AA    4E 55 4D 42     VENUMB: DB      "NUMBER = $"    ;SCREEN OUTPUT FOLLOWS....
04AE    45 52 20 3D
04B2    20 24
04B4    53 4C 4F 50     VESLOP: DB      "SLOPE = $"     ;
```

```
                                        ;
                                        ; THIS ROUTINE ISSUES  'V 0' ,'V 2', AND 'V 3'
                                        ; TO THE ACTIVE CY512 AND PRINTS OUT ITS STATUS.
                                        ; PULSES FROM HOME, NUMBER, RATE, SLOPE, FACTOR,
                                        ; DIRECTION, AND STEP MODE.
                                        ;
03C3    CD 06A2                         VERIFY: CALL    SAVREG          ;
03C6    CD 058D                                 CALL    HOME            ;CLEAR THE DISPLAY.
03C9    21 049E                                 LD      HL,VZERO        ;SEND 'V 0' TO THE CY 512...
03CC    CD 046C                                 CALL    VEOTPT          ;......
03CF    11 0505                                 LD      DE,PEQUAL       ;PNT 'PULSES FROM HOME =' AND..
03D2    CD 0581                                 CALL    PRINT           ;.....
03D5    3E 00                                   LD      A,0             ;CLEAR THE COUNT USED TO GET...
03D7    CD 0541                         VELOOP: CALL    GETCY           ;FIVE BYTES OF DATA..
03DA    CD 058C                                 CALL    WICHR           ;..FROM THE CY 512..
03DD    3C                                      INC     A               ;..THAT MAKE UP THE PULSE COUNT.
03DE    FE 05                                   CP      5               ;ARE WE DONE YEY ?
03E0    C2 03D7                                 JP      NZ,VELOOP       ;NO, GO GET ANOTHER BYTE.
03E3    CD 05A3                                 CALL    CRLF            ;YES,....
03E6    21 04A2                                 LD      HL,VTWO         ;NOW SEND 'V 2' TO THE CY 512.
03E9    CD 046C                                 CALL    VEOTPT          ;......
03EC    3E 06                                   LD      A,6             ;PREPARE TO GET 6 BYTES OF DATA...
03EE    32 0497                                 LD      (VCOUNT),A      ;...FROM THE CY 512..
03F1    CD 047A                                 CALL    VFETCH          ;GO GET THEM.
03F4    21 04A6                                 LD      HL,VTHREE       ;NOW SEND 'V 3' TO THE CY 512.
03F7    CD 046C                                 CALL    VEOTPT          ;.....
03FA    3E 05                                   LD      A,5             ;RETRIEVE 5 BYTES OF DATA FROM CY512..
03FC    32 0497                                 LD      (VCOUNT),A      ;..OVERWRITING 1'ST 5 BYTES OF ....
03FF    CD 047A                                 CALL    VFETCH          ;..PREVIOUS FETCH.
                                        ;
                                        ;WE NOW HAVE THE DATA AND WILL PRINT OUT A STATUS DISPLAY.
                                        ;
0402    DD 21 0498                      VEDSPY: LD      IX,NUMBER       ;SET UP POINTER TO STATUS BUFFER.
0406    DD 66 00                                LD      H,(IX)          ;GET THE 'PULSE COUNT' ..
0409    DD 6E 01                                LD      L,(IX+1)        ;..READY FOR PRINTOUT.
040C    11 04AA                                 LD      DE,VENUMB       ;PRINT 'NUMBER = ' ON ...
040F    CD 0581                                 CALL    PRINT           ;...THE DISPLAY
0412    CD 058C                                 CALL    BDCONV          ;..AND TYPE OUT THE COUNT.
0415    26 00                                   LD      H,0             ;GET THE 'SLOPE CNT' READY..
0417    DD 6E 02                                LD      L,(IX+2)        ;..FOR PRINTOUT.
041A    11 04B4                                 LD      DE,VESLOP       ;PRINT 'SLOPE = ' ON..
041D    CD 0581                                 CALL    PRINT           ;...THE DISPLAY.
0420    CD 058C                                 CALL    BDCONV          ;CONVERT TO ASCII & PRINT SLOPE.
0423    26 00                                   LD      H,0             ;GET 'RATE' COUNT READY...
0425    DD 6E 03                                LD      L,(IX+3)        ;...FOR PRINTOUT.
0428    11 04BD                                 LD      DE,VERATE       ;PRINT 'RATE = ' ON ...
042B    CD 0581                                 CALL    PRINT           ;..THE DISPLAY....
042E    CD 058C                                 CALL    BDCONV          ;..AND CONVERT TO ASCII & PNT RATE.
0431    26 00                                   LD      H,0             ;GET 'FACTOR' READY...
0433    DD 6E 04                                LD      L,(IX+4)        ;..FOR PRINTOUT.
0436    11 04C5                                 LD      DE,VEFACT       ;PRINT 'FACTOR =' ON...
0439    CD 0581                                 CALL    PRINT           ;..THE DISPLAY.
043C    CD 058C                                 CALL    BDCONV          ;..CONV TO ASCII & PRINT OUT FACTOR.
043F    DD CB 05 66                             BIT     4.(IX+5)        ;IS THE 'CCW' BIT SET IN 'STATUS' BYTE ?
0443    CA 0460                                 JP      Z,VECW          ;NO, GO PRINTOUT 'CW' ON DISPLAY.
0446    11 04F2                                 LD      DE,VECCWM       ;YES, PRINT .....
```

```
                                 ;
                                 ;
0335    01 0025                  DTASTR: LD      BC,37           ;PREPARE TO COMPARE 37 CHARACTERS
0338    21 038B                          LD      HL,CHRLST       ;IN THE CHARACTER LIST WITH
033B    ED B1                            CPIR                    ;CHARACTER IN THE 'A' REGISTER..
033D    C2 036D                          JP      NZ,INVALD       ;IS THE CHARACTER VALID??
0340    FE 56                            CP      "V"             ;IS CHR A 'VERIFY ?
0342    CA [illegible]                   JP      Z,DTVFY         ;YES, GO DO A 'VERIFY.
0345    FE 51                            CP      "Q"             ;IS CHR A 'QUIT' ?
0347    CA 0384                          JP      Z,SQUIT         ;YES, GO SET 'DONEFLG' TO STOP 'CR'.
034A    FE 0D                            CP      13              ;IS CHR A 'CARRIAGE RETURN' ?
034C    C2 0353                          JP      NZ,VLDCHR       ;NO, PROCESS CHARACTER.
034F    FD CB 00 CE                      SET     1,(IY)          ;YES, SET 'CR' FLAG TO STOP LATER XTFR.
0353    FE 2C                    VLDCHR: CP      ","             ;YES: NOW SEE IF ITS A ","..
0355    C2 035E                          JP      NZ,SEND         ;NO, IT'S GOOD AS IS . USE IT.
0358    FD CB 00 DE                      SET     3,(IY)          ;SET UP A CY512 'RESET'.
035C    3E 0D                            LD      A,13            ;CHANGE THE ',' TO A 'CARRIAGE RETURN'..
035E    CD 0519                  SEND:   CALL    SENDCY          ;SEND THE CHARACTER TO THE ACTIVE CY512.
0361    FD CB 00 5E                      BIT     3,(IY)          ;SHALL WE 'RESET' ?
0365    C2 036C                          JP      NZ,DTAEXT       ;......
0368    FD CB 00 9E                      RES     3,(IY)          ;CLEAR RESET FLAG.
036C    C9                       DTAEXT:         RET             ;EXIT THE DATA STRING SUBROUTINE..
036D    FD CB 00 CE              INVALD: SET     1,(IY)          ;SET THE 'DONE FLAG'.
0371    11 03B0                          LD      DE,NVLDMG       ;TYPE ERROR MESSAGE 'INVALID COMMAND'.
0374    CD 0581                          CALL    PRINT           ;...
0377    C3 036C                          JP      DTAEXT          ;...
                                 ;
037A    FD CB 00 CE              DTVFY:  SET     1,(IY)          ;SET DONEFLG AND...
037E    CD 03C3                          CALL    VERIFY          ;..GO RUN A CY512 'VERIFY' ON ACTV UNIT.
0381    C3 036C                          JP      DTAEXT          ;..AND EXIT.
                                 ;
0384    FD CB 00 CE              SQUIT:  SET     1,(IY)          ;SET DONEFLG AND...
0388    C3 035E                          JP      SEND            ;..SEND 'Q' COMMAND.
                                 ;
038B    2C 41 42 43              CHRLST: DB      ",ABCDEFGHIJLNOPQRSTUVWX+-0123456789 ",13;VLID CHAR LIST
038F    44 45 46 47
0393    48 49 4A 4C
0397    4E 4F 50 51
039B    52 53 54 55
039F    56 57 58 2B
03A3    2D 30 31 32
03A7    33 34 35 36
03AB    37 38 39 20
03AF    0D
03B0    49 4E 56 41              NVLDMG: DB      "INVALID COMMAND",13,10,7,"$"
03B4    4C 49 44 20
03B8    43 4F 4D 4D
03BC    41 4E 44 0D
03C0    0A 07 24
                                 ;
                                 ;
                                 ;
                                 ;*************************************************
                                 ;*              VERIFY
                                 ;*      CY 512 INPUT DATA
                                 ;*************************************************
```

```
0208    4C 45 44 20
020C    43 48 41 52
02E0    41 43 54 45
02E4    52 21 0D 0A
02E8    07 24
                              ;
02EA    32 029C               CDCYUD: LD     (ACYNUM),A      ;UPDATE THE 'CYNUM  AND
02ED    D6 41                         SUB    65              ;
02EF    32 028B                       LD     (CYNUM),A       ;
02F2    CD 0306                       CALL   CYUPDT          ;GO UPDATE THE ACTIVE CY512 ADDRESS.
02F5    C3 02CA                       JP     CDEXIT          ;..
                              ;
02F8    32 028F               CDBDUD: LD     (ABOARD),A      ;UPDATE THE ACTIVE 'BOARD ..
02FB    D6 31                         SUB    49              ;
02FD    32 028D                       LD     (BOARD),A       ;...
0300    CD 0306                       CALL   CYUPDT          ;GO UPDATE ACTIVE CY512 ADDRESS.
0303    C3 02CA                       JP     CDEXIT          ;..
                              ;
                              ;
                              ;
                              ;UPDATES THE ACTIVE CY512 STATUS, CONTROL, AND DATA REGISTER ADDRESSES.
                              ;
0306    CD 06A2               CYUPDT: CALL   SAVREG          ;
0309    ED 5B 028B                    LD     DE,(CYNUM)      ;COMBINE 'CYNUM' AND
030D    2A 028D                       LD     HL,(BOARD)      ;..'BOARD' TO GENERATE THE
0310    CB 05                         RLC    L               ;..ACTIVE CY512 STAT, CTRL,
0312    CB 05                         RLC    L               ;..AND DATA REGISTER..
0314    CB 05                         RLC    L               ;..ADDRESSES.
0316    19                            ADD    HL,DE           ;...
0317    11 E0FC                       LD     DE,STAT         ;,,,
031A    19                            ADD    HL,DE           ;...
031B    22 0322                       LD     (CYCTRL),HL     ;SAVE THE ADDRESS OF CY512 CTRL REG.
031E    CD 06B5                       CALL   RESTOR          ;
0321    C9                                   RET             ;EXIT THE ACTIVE CY512 UPDATE S/R.
0322    00                    CYCTRL: 0                      ;STORE THE ACTIVE CY512 CTRL REG HERE.
0323    00                            0                      ;CYDATA ADDRESS IS CYCTRL ADDRESS+4.
                              ;
                              ;
0324    CD 0303               CDVFY:  CALL   VERIFY          ;GO EXECUTE THE 'VERIFY' COMMAND.
0327    C3 02CA                       JP     CDEXIT          ;RETURN TO EXIT CHECK.
                              ;DEFINITION FOLLOWS
                              ;
                              ;
032A    51 31 32 41           CMDLST: DB     "Q12ABC"        ;VALID COMMAND CHARACTERS.
032E    42 43
0330    41 42 43              CDLST1: DB     "ABC"           ;VALID CY512 CHAR'S.
0333    31 32                 CDLST2: DB     "12"            ;VALID BOARD NUMBERS.
                              ;
                              ;
                              ;
                              ;
                              ;
                              ;DATA STRING PROCESSING ROUTINE
                              ;THE CHARACTER IN THE 'A' REGISTER IS COMPARED AGAINST
                              ;THE VALID CHARACTER LIST, AND IF VALID -
                              ; SENDS IT TO THE ACTIVE CY512.  ","'S ARE CHANGED TO CARRIAGE RETURN'S.
```

```
000A                    GETSTR  EQU     10      ;READ IN A BUFFER STRING
000D                    CR      EQU     13      ;EXECUTES A CARRIAGE RETURN ON SCREEN
000A                    LF      EQU     10      ;EXECUTES A LINE FEED ON SCREEN
                        ;
                        ;
                        ;:::::::::::::::::::::::::::::
                        ;: CY I/O LOCATIONS          :
                        ;: & PROGRAM VARIABLES       :
                        ;:::::::::::::::::::::::::::::
                        ;
0007                    SLOT    EQU     7H              ;CYDRIVER APPLE 'SLOT' LOCATION.
F022                    TOPLINE EQU
                                        0E022H  ;TOP LINE OF SCREEN
    E0F0                        STAT    EQU     0E080H+SLOT*10H ;
                                ;
                                ;
                                ;
                                ;:::::::::::::::::::::::::::::
                                ;* INITIALIZE SCREEN AND VARIABLES
                                ;:::::::::::::::::::::::::::::
    0200    21 17FF             BKGND:  LD      HL,17FFH        ;SET UP USER STACK POINTER.
    0203    22 069E                     LD      (USRSTK),HL     ;.....
    0206    21 1000                     LD      HL,1000H        ;SET UP SYSTEM STACK PNTR.
    0209    F9                          LD      SP,HL           ;....
    020A    CD 058D                     CALL    HOME            ;CLEAR THE DISPLAY SCREEN.
    020D    11 0750                     LD      DE,HEADER       ;ROUTINE TO WRITE HEADER
    0210    CD 0581                     CALL    PRINT           ;TO THE SCREEN.
    0213    FD 21 027C                  LD      IY,FLGREG       ;USE IY TO POINT TO FLAG REGISTER.
    0217    3E 04                       LD      A,4
    0219    32 F022                     LD      (TOPLINE),A     ;SET TOP OF SCREEN 4 ROWS DOWN
    021C    CD 058D             RESTRT: CALL    HOME            ;CLEAR THE SCREEN
    021F    CD 0306                     CALL    CYUPDT          ;SET UP CYNUM ADDRESS.
    0222    CD 056C                     CALL    RESET           ;'RESET' THE CY512'S.
    0225    3E 3E                       LD      A,62
    0227    32 0710                     LD      (BUFF),A        ;SET STRING BUFFER TO MAX LENGTH
    022A    3E 00               LOOP:   LD      A,0             ;CLEAR LOOP FLAGS
    022C    32 027C                     LD      (FLGREG),A      ;...
    022F    01 003E                     LD      BC,62           ;LOAD THE INPUT BUFFER WITH...
    0232    21 06D0                     LD      HL,CRRTN        ;..CARRIAGE RETURN SYMBOLS
    0235    11 0712                     LD      DE,BUFF+2       ;...
    0238    ED B0                       LDIR                    ;UNTIL BUFFER FULL.
    023A    DD 21 0712                  LD      IX,BUFF+2       ;SET INDEX TO START OF BUFFER
    023E    11 028F                     LD      DE,PROMPT-2     ;SET UP PRINT 'PROMPT'
    0241    CD 0581                     CALL    PRINT           ;AND PRINT PROMPT LINE.
    0244    CD 0293                     CALL    INPSTR          ;GO GET A CHARACTER STRING.
    0247    CD 05A3                     CALL    CRLF            ;ENHANCE SCREEN OUTPUT.
    024A    DD 7E 00            MORCHR: LD      A,(IX)          ;LOAD 'A' REG WITH CHAR.
    024D    DD 23                       INC     IX              ;ADVANCE BUFFER PNTR TO NEXT CHAR.
    024F    FE 2F               CHAR:   CP      "/"             ;DOES A 'COMMAND STRING FOLLOW ?
    0251    CA 0275                     JP      Z,SETSW         ;YES, SET COMMAND SWITCH.
    0254    FD CB 00 56                 BIT     2,(IY)          ;IS COMMAND SWITCH SET ?
    0258    CA 026F                     JP      Z,DATASG        ;NO,.......
    025B    CD 029C                     CALL    CMDSTR          ;YES, PROCESS COMMAND STRING.
    025E    FD CB 00 4E         EXIT:   BIT     1,(IY)          ;HAVE WE FINISHED PROCESSING THE STRING.
    0262    CA 024A                     JP      Z,MORCHR        ;NO,CONTINUE PROCESSING CHAR'S IN STR.
    0265    FD CB 00 46                 BIT     0,(IY)          ;IS IT TIME TO QUIT??
    0269    C2 027D                     JP      NZ,RTNCPM       ;IF YES, CLEAR SCREEN AND RETURN TO CP/M
```

July 1983

Functional System Prog

Step Motor Control Bd

Driver Program in

Z-80 Assembly Language

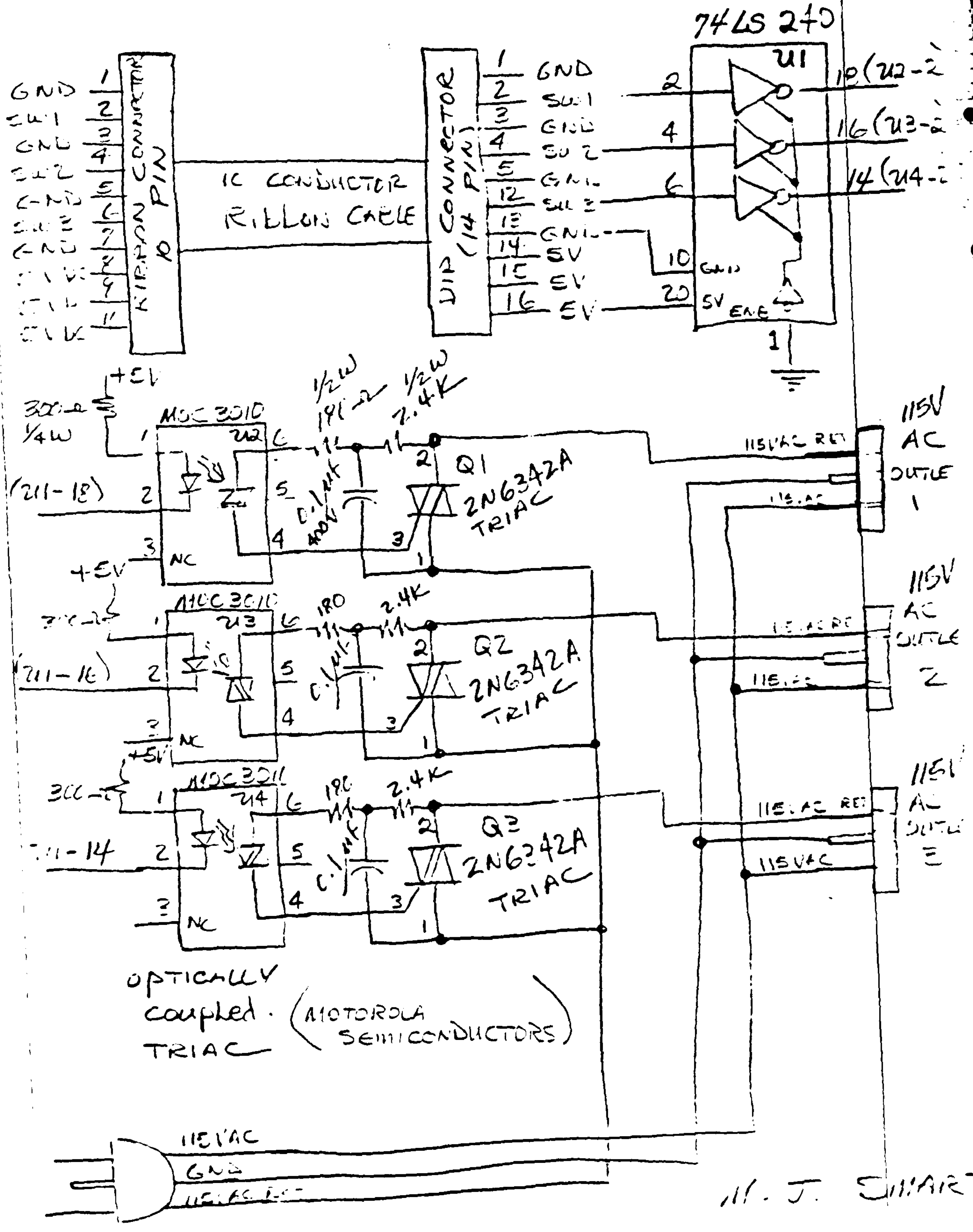
```
                              .Z80
0000'                         ASEG
                              ORG     200H
                        ;::::::::::::::::::::::::::::::
                        ;
                        ;:  MACHINE LANGUAGE          :
                        ;:   CY512 DRIVER             :
                        ;:                            :
                        ;::::::::::::::::::::::::::::::
                        ;
                        ;::::::::::::::::::::::::::::::
                        ;:      6502 MONITOR          :
                        ;:      SUBROUTINES           :
                        ;::::::::::::::::::::::::::::::
FC58                    A$HOME  EQU     0FC58H  ;CLEARS AND HOMES SCREEN
FF3A                    A$BELL  EQU     0FF3AH  ;DINGS THE BELL
FF2D                    A$PRERR EQU     0FF2DH  ;PRINTS "ERR" ON SCREEN AND DINGS BELL
                        ;
                        ;::::::::::::::::::::::::::::::
                        ;:      CALLING 6502 S/R'S    :
                        ;::::::::::::::::::::::::::::::
                        ;: ADDRESSES USED    PURPOSE  :
                        ;: Z-80   6502                :
                        ;: F045H  $45  6502 A REG XTFR:
                        ;: F046H  $46  6502 X REG XTFR:
                        ;: F047H  $47  6502 Y REG XTFR:
                        ;: F048H  $48  6502 P STATUS  :
                        ;: F049H  $49  6502 STACK PNTR:
                        ;: F3DEH (EN00H) ADDR OF SOFT:
                        ;: CARD IN LO-HI ORDER  :
                        ;: F3D0H ADDR OF 6502 S/R TO BE:
                        ;:CALLED IN LO-HI ORDER   :
                        ;:                            :
                        ;: SEE SOFTCARD MANUAL PG 2-24:
                        ;::::::::::::::::::::::::::::::
                        ;
                        ;: DEFINITIONS FOLLOW         :
                        ;
F3DE                    Z$CPU   EQU     0F3DEH  ;SOFTCARD LOCATION STORED HERE
F3D0                    A$VEC   EQU     0F3D0H  ;ADDR OF 6502 S/R STORED HERE
F045                    A$ACC   EQU     0F045H  ;6502 A REG STORE
F046                    A$XREG  EQU     0F046H  ;6502 X REG STORE
F047                    A$YREG  EQU     0F047H  ;6502 Y REG STORE
F048                    A$PREG  EQU     0F048H  ;6502 P REG STORE
F049                    A$SKPTR EQU     0F049H  ;6502 STACK PNTR STORE
                        ;
                        ;::::::::::::::::::::::::::::::
                        ;:                            :
                        ;: USEFUL CP/M SUBROUTINES    :
                        ;:                            :
                        ;::::::::::::::::::::::::::::::
                        ;
0005                    CPMNTRY EQU     5       ;CP/M ENTRY POINT
 01                     RCHAR   EQU     1       ;READ IN ONE CHARACTER
0002                    WCHAR   EQU     2       ;WRITE OUT ONE CHARACTER
0009                    PNTSTR  EQU     9       ;PRINT A BUFFER STRING
```

APPENDIX G

Machine Controller Software
(Assembly code for Z-80)

6 JUNE 83

LOGIC CONTROLLED AC POWER SWITCH (3 CHANNEL)



OPTICALLY coupled TRIAC (MOTOROLA SEMICONDUCTORS)

M. J. SMART

7 of the ribbon connector. Five volt power is required by this box for the 74LS 240 chip in the circuitry.

Logic Controlled AC Power Switch

Theory of Operation:

A triac is a back-to-back diode pair which is gate controlled. A small (50ma) gate current switches the diode pair into conduction and effectively closes the "AC power" circuit. The circuit remains closed so long as gate current is supplied.

If gate current is interrupted, the triac output circuit will be interrupted (disconnected) where the alternating AC voltage passes through its next zero crossing voltage - because the diode pair will go into their open/off state.

A Motorola 12 Amp/200 Volt triac (2N6342A) used as the switch in the 115 VAC ~~115V AC~~ output circuit is controlled by a small "optically excited" Motorola triac (MOC 3010). This small triac supplies the gate current for the power line triac. The MOC 3010 triac is switched on by a TTL high logic level applied to an 74LS 240 inverting buffer, the buffer output goes low, causing the LED in the MOC 3010 to emit light which switches the triac, internal to the MOC 3010, on. This in~~te~~ Turn allows gate current to flow to the 2N 6342A power triac and switch it on.

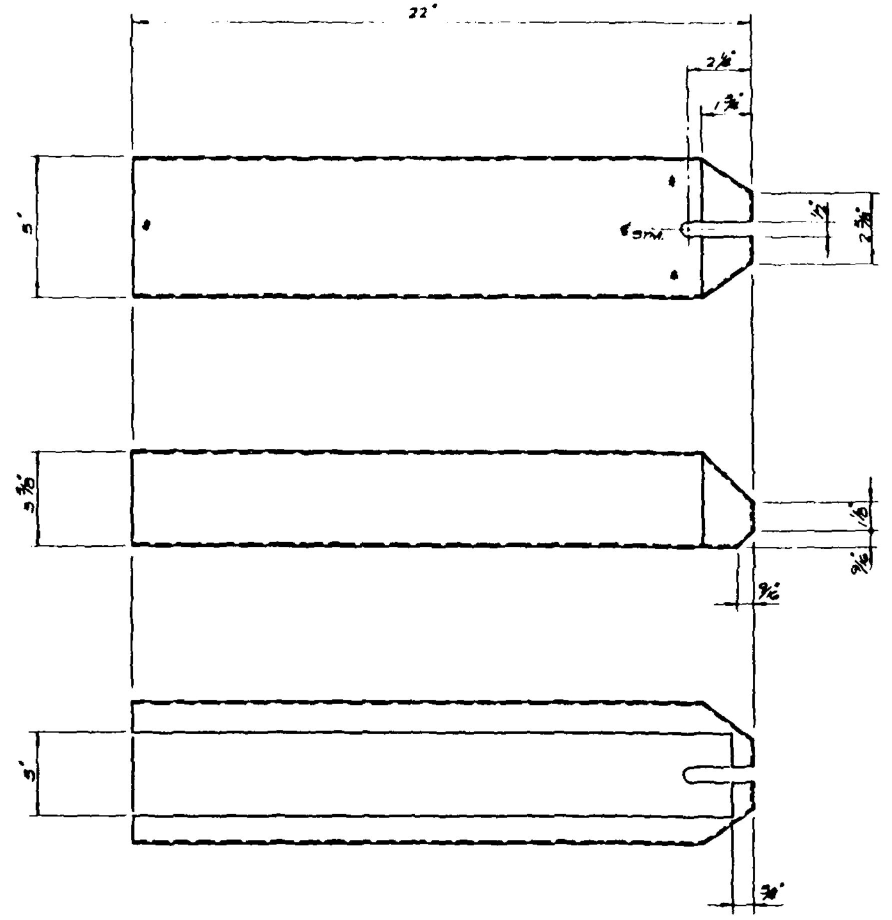
A low TTL level to the 74LS 240 buffer will extinguish all gate currents and the next zero crossing of the AC power line will cause both triacs to switch to their off states.

The RC network connected between the two triacs is for compensation due to the inductive load of the AC motor to be driven by the triac output.

The box must be plugged into the 115 VAC line with the plug provided. This line is fused with a 10 Amp fuse. The TTL logic signal is applied to pin 2, 4, or 6 on the ribbon connector to control outlet 1, 2, or 3. Apply +5 VDC to pins 8, 9, and 10 and +5 VDC return (ground) to pins 1, 3, 5, and

APPENDIX F

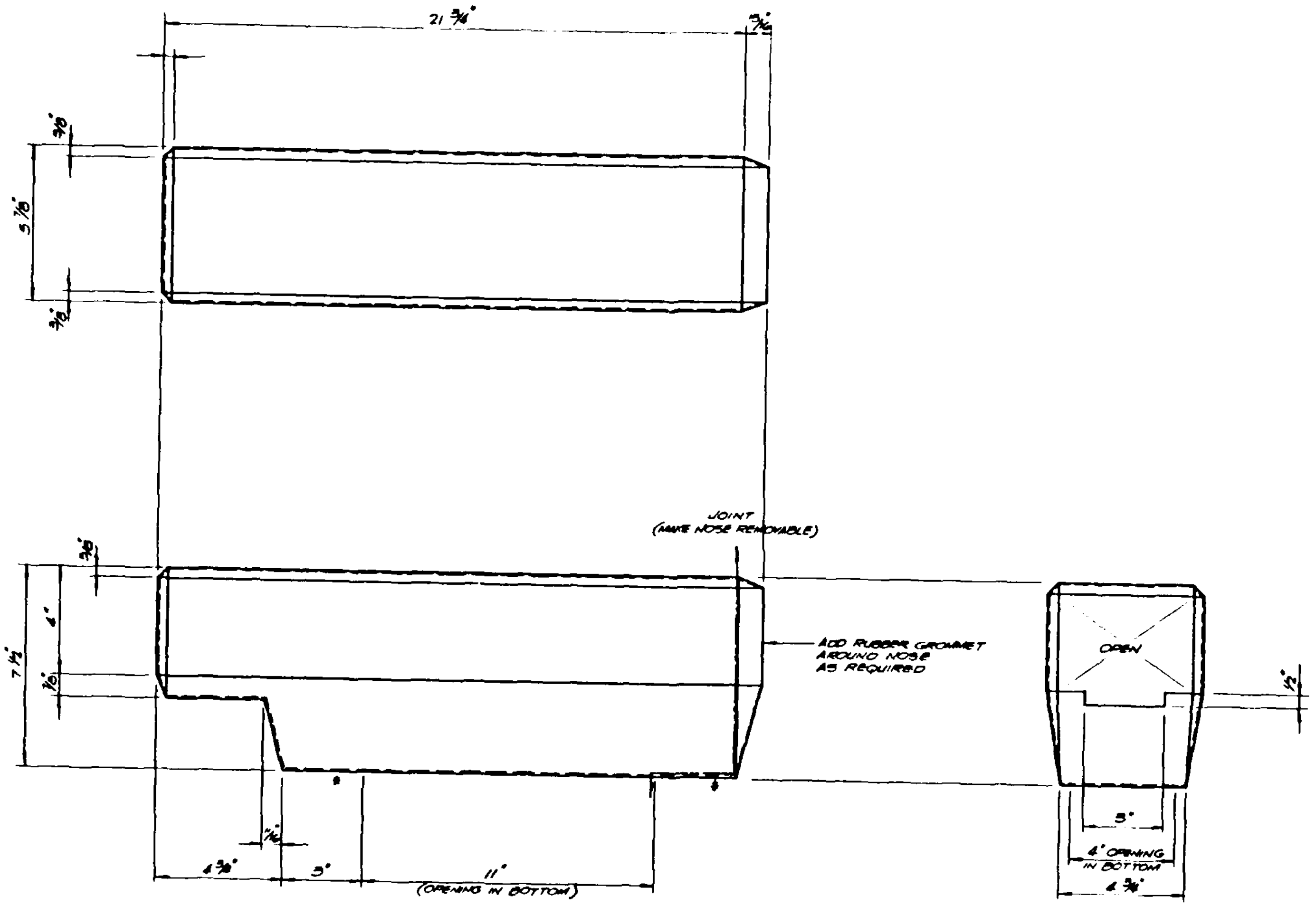
Documentation and Schematics for Logic Controlled AC Power Switch



DETAIL ITEM (32) (ACRYLIC OR EQUAL)
— 1/2 SCALE

NOTES
1. ALL DIMENSIONS ARE INSIDE MEASUREMENTS.
2. • DENOTES POINTS OF ATTACHING TO FRAME.
3. PAINT AS REQUIRED.

MARCH 9, 1982 CAC AM DEPT.	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	ROBOT	DETAIL ITEM 32	FORREST BLAIR	0029



DETAIL ITEM (31) (ACRYLIC OR EQUAL)
— 1/2 SCALE

NOTES

1. ALL DIMENSIONS ARE INSIDE MEASUREMENTS.
2. • DENOTES POINTS OF ATTACHING TO FRAME.
3. ADD VENTILATION LOUVERS AS REQUIRED.
4. PAINT AND APPLY LOGO AS REQUIRED.

MARCH 9, 1982 CAD-CAM DEPT	BRIGHAM YOUNG UNIVERSITY PROVO UTAH 84602	ROBOT	DETAIL ITEM 31		FORREST BLAIR	0028

```
                                ;*
                                ;* THE CHARACTER IS RETURNED IN THE 'E' REGISTER.
                                ;****************************************************
                                ;
0541    CD 06A2                 GETCY:  CALL    SAVREG          ;SAVE PROCESSOR REGS.
0544    FD 2A 0322                      LD      IY,(CYCTRL)     ;SET POINTER TO CY512 CONTROL REG.
0548    2E 42                           LD      L,42H           ;SET CTRL REG FOR CY512 'OUTPUT'!
054A    FD 75 00                        LD      (IY),L          ;......
054D    FD CB 00 56             BWAIT1: BIT     2,(IY)          ;CHECK CY512 STATUS..IS IT BUSY?
0551    CA 054D                         JP      Z,BWAIT1        ;YES,  WAIT
0554    2E 43                           LD      L,43H           ;READY, MAKE AN I/O REQUEST.
0556    FD 75 00                        LD      (IY),L          ;.....
0559    FD CB 00 56             BWAIT2: BIT     2,(IY)          ;IS THE CY512 DATA READY?
055D    C2 0559                         JP      NZ,BWAIT2       ;NO,,WAIT 'TIL DATA IS READY.
0560    FD 5E 04                        LD      E,(IY+4)        ;YES,FETCH CY512 OUTPUT CHARACTER.
0563    2E 40                           LD      L,40H           ;CLEAR THE I/O REQUEST....
0565    FD 75 00                        LD      (IY),L          ;...AND SET UP FOR CY INPUT.
0568    CD 06B9                         CALL    RESTOR          ;RESTORE ACTIVE REGISTERS.
056B    C9                                      RET             ;EXIT THE GET CHARACTER S/R..
                                ;
                                ;
                                ;
                                ;**************************************************
                                ;*    RESET  THE ACTIVE CY512
                                ;*
                                ;* THIS ROUTINE SETS UP THE ACTIVE CY512 FOR PROPER COMMUNICATION.
                                ;**************************************************
                                ;
056C    CD 06A2                 RESET:  CALL    SAVREG          ;SAVE PROCESSOR REGISTERS.
056F    FD 2A 0322                      LD      IY,(CYCTRL)     ;
0573    3E 44                           LD      A,44H           ;THE ACTIVE CY512...
0575    FD 77 00                        LD      (IY),A          ;..IS SET TO ASCII MODE AND..
0578    3E 40                           LD      A,40H           ;..IS THEN 'RESET', AND..
057A    FD 77 00                        LD      (IY),A          ;..THE RESET BIT IS CLEARED.
057D    CD 06B9                         CALL    RESTOR          ;RETURN ACTIVE REGISTERS.
0580    C9                                      RET             ;EXIT THE 'RESET' S/R.
                                ;
                                ;
                                ;**************************************************************
                                ;*              PRINT MESSAGE SUBROUTINE
                                ;:
                                ;* PRINTS MESSAGE WHOSE STARTING ADDRESS IS IN THE 'DE' REGISTER
                                ;* AND PRINT UNTIL A '$' SYMBOL IS INTERCEPTED.
                                ;**************************************************************
                                ;
                                ;
0581    CD 06A2                 PRINT:  CALL    SAVREG          ;...SAVE REGISTERS.
0584    0E 09                           LD      C,PNTSTR        ;S/R TO PRINT A CHARACTER STRING.
0586    CD 0005                         CALL    CPMNTRY         ;
0589    CD 06B9                         CALL    RESTOR          ;RESTORE THE REGISTERS.
058C    C9                                      RET             ;
                                ;
                                ;
                                ;****************************************************
                                ;*       'HOME' AND CLEAR DISPLAY SCREEN
                                ;****************************************************
```

```
                            ;
                            ;
058D    CD 06A2             HOME:   CALL    SAVREG          ;SAVE ACTIVE REGS.
0590    11 FC58                     LD      DE,A$HOME       ;SET UP 6502 VECTOR LOCATION
0593    ED 53 F3D0                  LD      (A$VEC),DE      ;TO CLEAR AND HOME SCREEN
0597    2A F3DE                     LD      HL,(Z$CPU)      ;GET Z80 SOFTCARD STARTING LOCATION
059A    CD 05A1                     CALL    SOFTCD          ;EXECUTE THE REQUEST
059D    CD 06B9                     CALL    RESTOR          ;RESTORE THE REGISTERS.
05A0    C9                                  RET
                            ;
                            ;
05A1    77                  SOFTCD: LD      (HL),A          ;ACTIVATE SOFTCD TO DO 6502 S/R.
05A2    C9                                  RET
                            ;
                            ;
05A3    11 000D             CRLF:   LD      DE,CR           ;SEND A CR/LF TO THE SCREEN
05A6    CD 05B0                     CALL    WICHR           ;
05A9    11 000A                     LD      DE,LF           ;
05AC    CD 05B0                     CALL    WICHR           ;
05AF    C9                                  RET
                            ;
                            ;
05B0    CD 06A2             WICHR:  CALL    SAVREG          ;SAVE PROCESSOR REGISTERS.
05B3    0E 02                       LD      C,WCHAR         ;THIS ROUTINE TYPES THE CHAR ...
05B5    CD 0005                     CALL    CPMNTRY         ;..STORED IN THE 'DE' REGISTER
05B8    CD 06B9                     CALL    RESTOR          ;RESTORE THE REGISTERS.
05BB    C9                                  RET             ;.
                            ;
                            ;
                            ;**********************************************
                            ;*THIS SUBROUTINE CONVERTS THE TWO BYTE
                            ;*NUMBER IN THE HL REGISTER TO A FIVE
                            ;*DECIMAL DIGIT NUMBER STORED IN FIVE
                            ;*SEQUENTIAL REGISTERS.
                            ;**********************************************
                            ;
                            ;   BINARY TO DECIMAL TO ASCII CONVERT ROUTINE.
                            ;
05BC    CD 06A2             BDCONV: CALL    SAVREG          ;SAVE PROCESSOR REGISTERS
05BF    FD 21 0696                  LD      IY,BDFLG        ;CLEAR 'CARRY' ,COUNTER,
05C3    DD 21 069D                  LD      IX,ANSBUF+4     ;SET UP ANS BUFFER POINTER.
05C7    FD 36 02 05                 LD      (IY+2),5        ;SET CTR FOR FIVE DECIMAL DIGITS.
05CB    37                  BDLOOP: SCF                     ;CLEAR 'CARRY' FLAG AND...
05CC    3F                          CCF                     ;....
05CD    FD 36 00 00                 LD      (IY),0          ;SKIP,COUNT,AND DONE FLAGS.
05D1    01 1080                     LD      BC,1080H        ;INITIALIZE 'BC  TO GENERATE QUOTIENT.
05D4    11 A000                     LD      DE,0A000H       ;AND LOAD DE WITH THE 'NEW BASE'
05D7    3E 00                       LD      A,0             ;...
05D9    ED 52               BDCONT: SBC     HL,DE           ;BEGIN THE DIVIDING BY NEW BASE
05DB    D2 05E3                     JP      NC,BDNEXT       ;IF (HL) POSITIVE, CONTINUE.
05DE    19                          ADD     HL,DE           ;WON'T GO, RESTORE ORIGINAL NUMBER.
05DF    FD CB 00 D6                 SET     2,(IY)          ;AND SET THE 'SKIP ADD QUOTIENT' FLAG.
05E3    CB 3A               BDNEXT: SRL     D               ;ROTATE DE 'RIGHT' ONE BIT
05E5    CB 1B                       RR      E               ;...
05E7    FD CB 00 4E                 BIT     1,(IY)          ;HAVE WE ROTATED FIVE TIMES YET?
05EB    C2 0606                     JP      NZ,BDLSB        ;YES, WORK ON LSB BYTE.
```

```
05EE    FD CB 00 56             BIT     2,(IY)          ;NO, SO IS SKIP FLAG SET?
05F2    C2 05F6                 JP      NZ,BDADV        ;YES, BYPASS THE ADD PARTIAL PRODUCT.
05F5    80                      ADD     A,B             ;NO,, ADD A BIT TO QUOTIENT.
05F6    CB 38           BDADV:  SRL     B               ;SHIFT BIT COUNTER AND SEE OF ITS ZERO
05F8    C2 0688                 JP      NZ,BDLINK       ;NO,GO CLEAR SKIP FLAG AND CONT DIVIDE.
05FB    3F                      CCF                     ;YES, CLEAR 'CARRY',
05FC    FD CB 00 CE             SET     1,(IY)          ;SET LSB FLAG(FIVE SHIFTS) AND
0600    47                      LD      B,A             ;SAVE PARTIAL DIVIDE QUOTIENT...
0601    3E 00                   LD      A,0             ;..QUOTUH AND CLEAR THE 'A' REG.
0603    C3 0688                 JP      BDLINK          ;AND CONTINUE.
0606    FD CB 00 56     BDLSB:  BIT     2,(IY)          ;CHECK THE SKIP FLAG ?
060A    C2 060E                 JP      NZ,BDINC                ;BYPASS THE ADD IF SET.
060D    81                      ADD     A,C             ;NOPE.. ADD A BIT TO THE QUOTIENT.
060E    CB 39           BDINC:  SRL     C               ;SHIFT BIT CTR AND TEST FOR 13 SHIFTS.
0610    C2 0688                 JP      NZ,BDLINK       ;NOT YET, CLR SKIP FLG AND CONT DIV.
0613    3F                      CCF                     ;CLR CARRY FLAG AND SAVE 'QUOTLH'.
0614    4F                      LD      C,A             ;...
0615    7D                      LD      A,L             ;CONVERT THE REMAINDER TO ASCII...
0616    C6 30                   ADD     A,30H           ;...AND...
0618    DD 77 00                LD      (IX),A          ;STORE REM(DEC DIGIT) IN ANSBUFFER.
061B    DD 2B                   DEC     IX              ;MOVE ANSBUF POINTER TO NEXT LOC.
061D    60                      LD      H,B             ;MOVE 'QUOTIENT' TO 'HL' FOR
061E    69                      LD      L,C             ;FOR NEXT DIVIDE ROUND.
061F    FD 35 02                DEC     (IY+2)          ;DECREMENT 'FIVE DIGIT' CTR AND
0622    CA 068F                 JP      Z,BDFSET        ;PREPARE TO EXIT IF ZERO.
0625    FD CB 00 46     BDEXIT: BIT     0,(IY)          ;CHECK THE 'EXIT FLAG'....
0629    CA 05CE                 JP      Z,BDLOOP        ;NOT DONE..GET NEXT DIGIT.
062C    CD 0633                 CALL    PDIGTS          ;GO PRINT THE CONVERTED DIGITS.
062F    CD 06B9                 CALL    RESTOR          ;RESTORE PEGISTERS.
0632    C9                              RET             ;EXIT .............
                        ;
                        ;
0633    CD 06A2         PDIGTS: CALL    SAVREG          ;SAVE THE 'X' REGISTER.
0636    DD 21 0699              LD      IX,ANSBUF       ;SET IX POINTER TO 5 DIGIT BUFFER.
063A    FD 21 0687              LD      IY,PDIGFG       ;SET UP AND...
063E    3E 00                   LD      A,0             ;...CLEAR..
0640    32 0687                 LD      (PDIGFG),A      ;..FLAG BITS.
0643    3E 04                   LD      A,4             ;SET UP DIGIT COUNTER.
0645    FE 00           PDLOOP: CP      0               ;IS CNTR TO 5TH DIGIT YET?
0647    C2 0672                 JP      NZ,PDELSE       ;NO,  CONTINUE.
064A    FD CB 00 C6             SET     0,(IY)          ;SET FLAGS...
064E    FD CB 00 CE             SET     1,(IY)          ;...
0652    FD CB 00 4E     PDCONT: BIT     1,(IY)          ;ARE WE STILL RECEIVING LEADING ZEROS?
0656    CA 0661                 JP      Z,PDOUT         ;NO, CONTINUE.
0659    16 00                   LD      D,0             ;
065B    DD 5E 00                LD      E,(IX)          ;LOAD DIGIT INTO OUTPUT REGISTER.
065E    CD 05B0                 CALL    WICHR           ;AND PRINT IT !
0661    DD 23           PDOUT:  INC     IX              ;INCREMENT DIGIT POINTER AND
0663    3D                      DEC     A               ;DECREMENT THE DIGIT COUNTER.
0664    FD CB 00 46             BIT     0,(IY)          ;ARE WE DONE YET ??
0668    CA 0645                 JP      Z,PDLOOP        ;NO, KEEP AT IT.
066B    CD 05A3                 CALL    CRLF            ;DONE,RTN CURSOR AND EXIT..
066E    CD 06B9                 CALL    RESTOR          ;RESTORE THE X REGISTER
0671    C9                              RET             ;.....
                        ;
0672    CD 06A2         PDELSE: CALL    SAVREG          ;SAVE THE COUNT AND
```

```
0675    DD 7E 00                     LD      A,(IX)          ;IS THE CHARACTER A '0' ??
0678    FE 30                        CP      30H             ;
067A    CA 0681                      JP      Z,PDNEX         ;YES, PREPARE TO EXIT
067D    FD CB 00 CE                  SET     1,(IY)          ;NO , SET LEADZERO FLAG.
0681    CD 0689              PDNEX:  CALL    RESTOR          ;RESTORE REGISTERS
0684    C3 0652                      JP      PDCONT          ;AND CONTINUE PROCESSING.
0687    00                   PDIGFG:         0               ;
                             ;
                             ;
0688    FD CB 00 9E          BDLINK: RES     2,(IY)          ;CLEAF THE 'SKIP' FLAG.
068C    C3 05D9                      JP      BDCONT          ;GO CONTINUE THE DIVIDE PROCESS.
068F    FD CB 00 C6          BDFSET: SET     0,(IY)          ;SET THE EXIT FLAG (DONE,FIVFLG).
0693    C3 0625                      JP      BDEXIT          ;......AND GO EXIT.
0696    00                   BDFLG:  0                       ;FLAG REGISTER.
0697    00                           0                       ;
0698    00                   BDCNT:  0                       ;DIGIT COUNTER.
0699    00                   ANSBUF: 0                       ;THIS IS THE FIVE DIGIT ANSWER BUFFER.
069A    00                           0                       ;...
069B    00                           0                       ;...
069C    00                           0                       ;..
069D    00                           0                       ;.
                             ;
                             ;
                             ;**************************************************
                             ;*          USER STACK AND SAVE PROCEEDURE
                             ;**************************************************
                             ;
069E    17                   USRSTK:         17H             ;SET THE USER STACK BELOW PROGRAM AREA.
069F    0F                                   0FH             ;
06A0    00                   SYSSTK:         0               ;SAVE SYSTEM STACK POINTER.
06A1    00                                   0               ;
                             ;
                             ;**************************************************
                             ;*    SAVE PROCESSOR REGISTERS
                             ;**************************************************
                             ;
06A2    ED 73 06A0           SAVREG: LD      (SYSSTK),SP     ;SAVE THE SYSTEM STACK POINTER.
06A6    ED 7B 069E                   LD      SP,(USRSTK)     ;LOAD USER STACK POINTER.
06AA    F5                           PUSH    AF              ;SAVE ACTIVE REGISTERS...
06AB    E5                           PUSH    HL              ;...
06AC    DD E5                        PUSH    IX              ;...
06AE    FD E5                        PUSH    IY              ;...
06B0    ED 73 069E                   LD      (USRSTK),SP     ;SAVE USRSTK POINTER.
06B4    ED 7B 06A0                   LD      SP,(SYSSTK)     ;RESTORE SYSTEM STACK POINTER.
06B8    C9                                   RET             ;..EXIT
                             ;
                             ;
                             ;**************************************************
                             ;*    RESTORE PROCESSOR REGISTERS
                             ;**************************************************
                             ;
06B9    ED 73 06A0           RESTOR: LD      (SYSSTK),SP     ;SAVE SYSTEM STACK PNTR.
06BD    ED 7B 069E                   LD      SP,(USRSTK)     ;LOAD USER STACK POINTER.
06C1    FD E1                        POP     IY              ;RESTORE THE ACTIVE REGISTERS.
06C3    DD E1                        POP     IX              ;...
06C5    E1                           POP     HL              ;...
```

```
06C6    F1                          POP     AF              ;...
06C7    ED 73 069E                  LD      (USRSTK),SP     ;SAVE USER STACK POINTER.
06CB    ED 7B 06A0                  LD      SP,(SYSSTK)     ;RESTORE SYSTEM STACK POINTER.
06CF    C9                                  RET             ;..AND EXIT
                              ;
                              ;                             ;SET UP STRING BUFFER SPACE,
06D0    0D 0D 0D 0D           CRRTN:  DB      13,13,13,13,13,13,13,13,13,13,13,13,13,13,13,13
06D4    0D 0D 0D 0D
06D8    0D 0D 0D 0D
06DC    0D 0D 0D 0D
06E0    0D 0D 0D 0D                   DB      13,13,13,13,13,13,13,13,13,13,13,13,13,13,13,13
06E4    0D 0D 0D 0D
06E8    0D 0D 0D 0D
06EC    0D 0D 0D 0D
06F0    0D 0D 0D 0D                   DB      13,13,13,13,13,13,13,13,13,13,13,13,13,13,13,13
06F4    0D 0D 0D 0D
06F8    0D 0D 0D 0D
06FC    0D 0D 0D 0D
0700    0D 0D 0D 0D                   DB      13,13,13,13,13,13,13,13,13,13,13,13,13,13,13,13
0704    0D 0D 0D 0D
0708    0D 0D 0D 0D
070C    0D 0D 0D 0D
0710                          BUFF:   DS      64              ;LOCATION BUFF+1 CONTAINS STR LENGTH
0750    2A 2A 2A 2A           HEADER: DB      '***************************************',13,10
0754    2A 2A 2A 2A
0758    2A 2A 2A 2A
075C    2A 2A 2A 2A
0760    2A 2A 2A 2A
0764    2A 2A 2A 2A
0768    2A 2A 2A 2A
076C    2A 2A 2A 2A
0770    2A 2A 2A 2A
0774    2A 2A 2A 0D
0778    0A
0779    2A 20 20 20                   DB      '*        CY512 CONTROL PROGRAM        *',13,10
077D    20 20 20 20
0781    20 43 59 35
0785    31 32 20 43
0789    4F 4E 54 52
078D    4F 4C 20 50
0791    52 4F 47 52
0795    41 4D 20 20
0799    20 20 20 20
079D    20 20 2A 0D
07A1    0A
07A2    2A 20 49 4E                   DB      '* IN Z80 ASSEMBLY CODE BY M. J. SMART *',13,10
07A6    20 5A 38 30
07AA    20 41 53 53
07AE    45 4D 42 4C
07B2    59 20 43 4F
07B6    44 45 20 42
07BA    59 20 4D 2E
07BE    20 4A 2E 20
07C2    53 4D 41 52
07C6    54 20 2A 0D
07CA    0A
```

```
07CB    2A 2A 2A 2A            DB      '***************************************',13,10,'$'
07CF    2A 2A 2A 2A
07D3    2A 2A 2A 2A
07D7    2A 2A 2A 2A
07DB    2A 2A 2A 2A
07DF    2A 2A 2A 2A
07E3    2A 2A 2A 2A
07E7    2A 2A 2A 2A
07EB    2A 2A 2A 2A
07EF    2A 2A 2A 0D
07F3    0A 24
                               END
```

```
Macros:

 Symbols:
 A$ACC   F045    A$BELL  FF3A    A$HOME  FC58    A$PREG  F048

 A$PRER  FF2D    A$SKPT  F049    A$VEC   F300    A$XREG  F046

A$YREG  F047    ABOARD  028F    ACYNUM  0290    ANSBUF  0699

BDADV   0556    BDCNT   0698    BDCONT  05D9    BDCONV  05BC
BDEXIT  0625    BDFLG   0698    BDFSET  068F    BDINC   060E
BDLINK  0688    BDLOOP  05CB    BDLSE   0606    BDNEXT  05E3
BKGND   0200    BOARD   028D    BUFF    0710    CDBDUD  02F8
CDCHBD  02CB    CDCYUD  02EA    CDEXIT  02CA    CDFSET  02C6
CDGOOD  02AC    CDLST1  0330    CDLST2  0333    CDMSG   0204
CDVFY   0324    CHAR    024F    CHRLST  038B    CMDLST  032A
CMDSTR  029C    CPMNTR  0005    CR      000D    CRLF    05A3
CPRTN   06D0    CYCTRL  0322    CYNUM   028B    CYUPDT  0306
DATASG  026F    DTAEXT  036C    DTASTR  0335    DTVFY   037A
EXIT    025E    FACTOR  049C    FLGREG  027C    GETCY   0541
GETSTR  000A    GWAIT1  054D    GWAIT2  0559    HEADER  0750
HOME    058D    INPSTR  0293    INVALD  036D    LF      000A
LOOP    022A    MORCHR  024A    NUMBER  0498    NVLDMG  0380
PDCONT  0652    PDELSE  0672    PDIGFG  0687    PDIGTS  0633
PDLOOP  0645    PDNEX   0681    PDOUT   0661    PEQUAL  0505
PNTSTR  0009    PRINT   0581    PROMPT  0291    RATE    049B
RCHAR   0001    RESET   056C    RESTOR  06B9    RESTRT  021C
RTNCPM  0270    SAVREG  06A2    SCHDSK  0531    SCWAIT  0520
SEND    035E    SENDCY  0519    SETSW   0275    SLOPE   049A
SLOT    0007    SOFTCD  05A1    SQUIT   0384    STAT    E0F0
STATUS  049D    SYSSTK  06AC    TOPLIN  F022    USRSTK  069E
VCOUNT  0497    VECCWM  04F2    VEDW    0460    VECWM   04E7
VEDSCT  0449    VEDSPY  0402    VEEXIT  0456    VEFACT  04C5
VEFLST  04DB    VEFS    0466    VEHLST  04CF    VELOOP  03D7
VENUMB  04AA    VEOTPT  046C    VERATE  04BD    VERIFY  03C3
VESLOP  04B4    VFETCH  047A    VFLOOP  0486    VLDCHP  0353
VOLOOP  046E    VTHREE  04A6    VTWO    04A2    VZERO   049E
W1CHR   05B0    WCHAR   0002    Z$CPL   F3DE



No  Fatal error(s)



 8)
```

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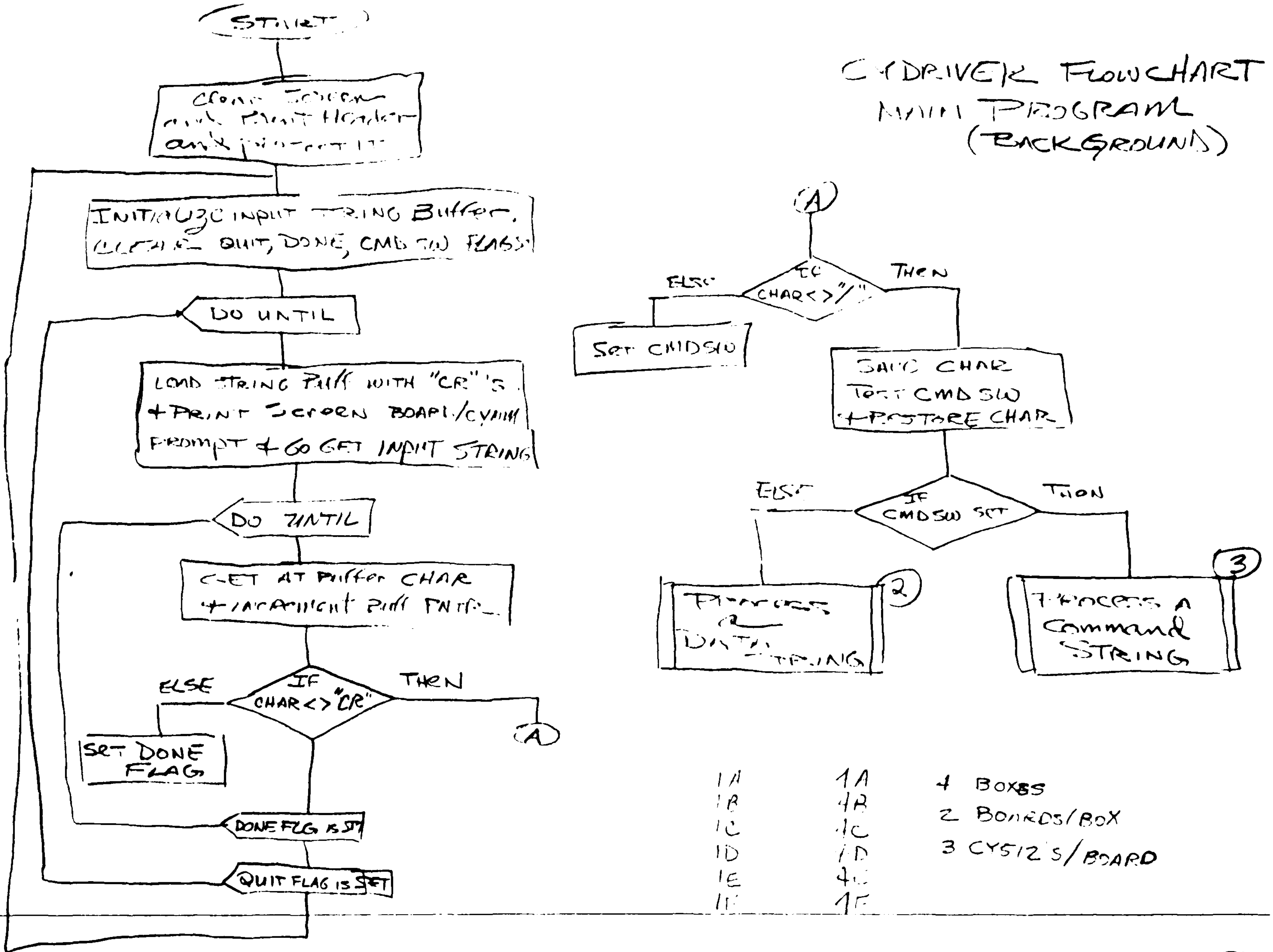
①

CYDRIVER FLOWCHART
MAIN PROGRAM
(BACKGROUND)



START
Clear Screen and Print Header and protect it
INITIALIZE INPUT STRING Buffer, CLEAR QUIT, DONE, CMD SW FLAGS
DO UNTIL
LOAD STRING BUFF WITH "CR"'S + PRINT SCREEN BOARD/CYNUM PROMPT + GO GET INPUT STRING
DO UNTIL
GET AT Buffer CHAR + INCREMENT BUFF PNTR
IF CHAR<>"CR"
THEN
ELSE
A
SET DONE FLAG
DONE FLG IS SET
QUIT FLAG IS SET
A
IF CHAR<>"/"
ELSE
THEN
SET CMDSW
SAVE CHAR TEST CMD SW + RESTORE CHAR
IF CMD SW SET
ELSE
THEN
Process a DATA STRING
2
Process A Command STRING
3

1A	1A	4 BOXES
1B	4B	2 BOARDS/BOX
1C	4C	3 CY512'S/BOARD
1D	1D	
1E	4[illegible]	
1F	1F	

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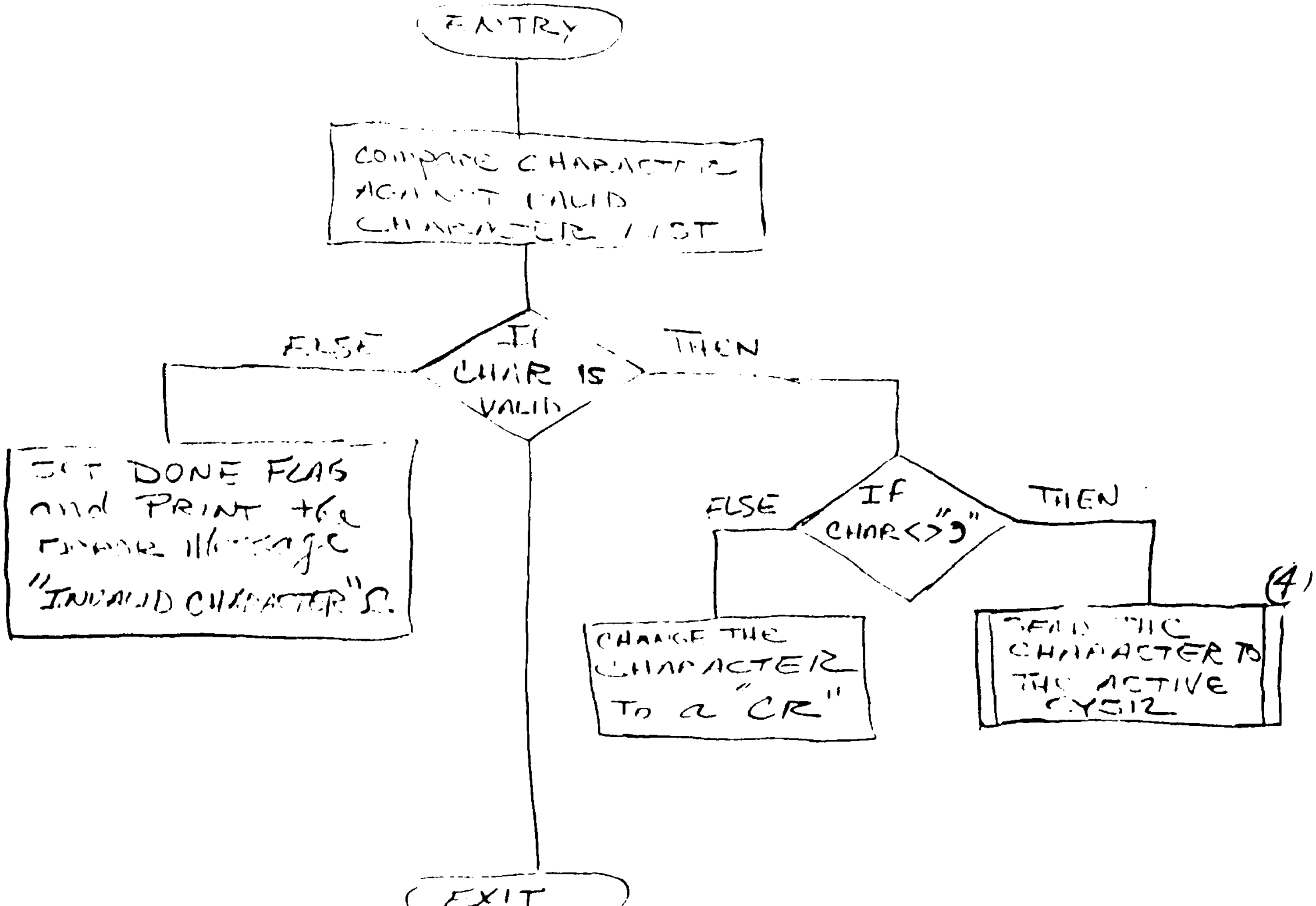
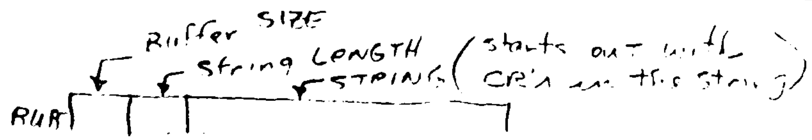
PROCESS DATA STRING S/R

2


ENTRY
COMPARE CHARACTER AGAINST VALID CHARACTER LIST
IF CHAR IS VALID
ELSE
THEN
SET DONE FLAG and PRINT the ERROR Message "INVALID CHARACTER"S.
IF CHAR<>"9"
ELSE
THEN
CHANGE THE CHARACTER To a "CR"
(4)
SEND THE CHARACTER TO THE ACTIVE USER
EXIT



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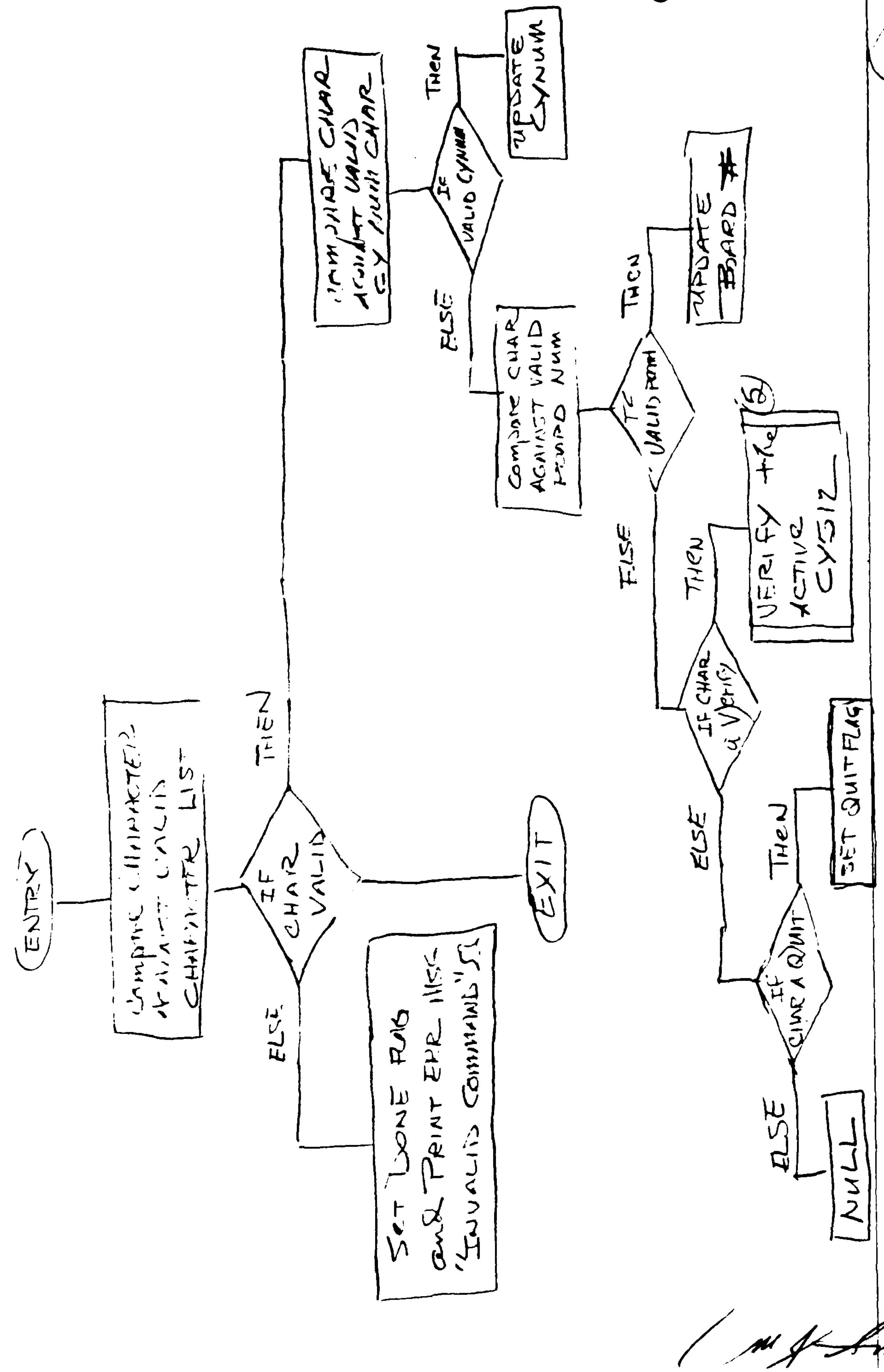
PROCESS COMMAND STRING 5/

3



APPENDIX H

Machine Language Interface and Communication Program

SOFTWARE:

MACHINE LANGUAGE INTERFACE AND COMMUNICATION PROGRAMS:

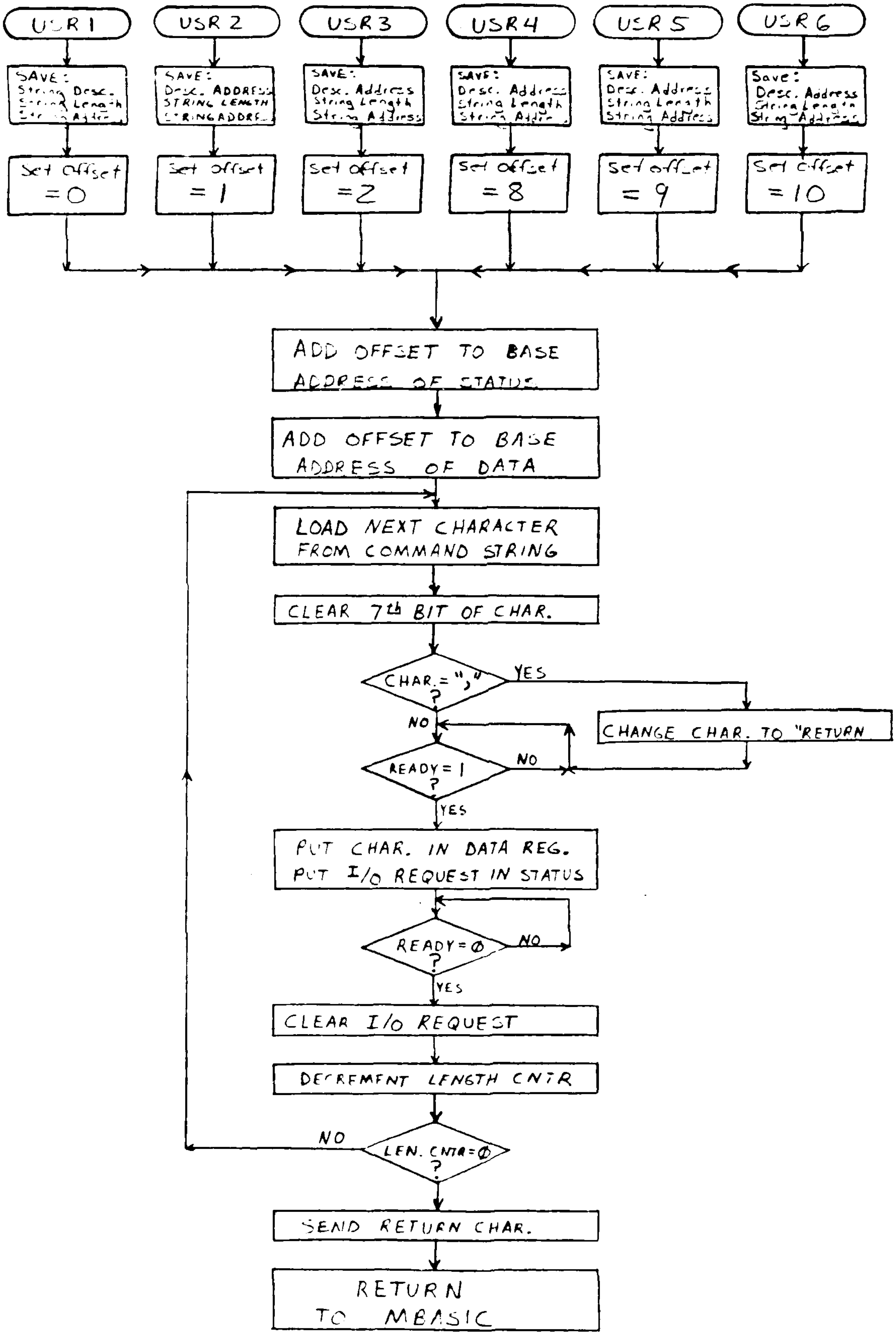
Following are assembler listings for two machine language programs which must be loaded to interface the APPLE computer to the "Blue Box" and to the serial RS232 card which allows communication with other computers. They are as follows:

CYDRIVER.HEX - The 8080 machine language program which allows Microsoft Basic to 'talk' with the "Blue Box"

COMM.HEX - The 8080 machine language program which allows Microsoft Basic to 'talk' with other computers and periferals through the RS232 interface card.

FIGURE 4 - Flow Chart

For details on the MBASIC "USR" Command, see Softcard Documentation Volume II, Appendix C.


USR 1
USR 2
USR 3
USR 4
USR 5
USR 6
SAVE: String Desc. String Length String Address
SAVE: Desc. ADDRESS STRING LENGTH STRING ADDRESS
SAVE: Desc. Address String Length String Address
SAVE: Desc. Address String Length String Address
SAVE: Desc. Address String Length String Address
Save: Desc. Address String Length String Address
Set Offset = 0
Set offset = 1
Set offset = 2
Set offset = 8
Set offset = 9
Set offset = 10
ADD OFFSET TO BASE ADDRESS OF STATUS
ADD OFFSET TO BASE ADDRESS OF DATA
LOAD NEXT CHARACTER FROM COMMAND STRING
CLEAR 7th BIT OF CHAR.
CHAR. = "," ?
YES
CHANGE CHAR. TO "RETURN
NO
READY = 1 ?
NO
YES
PUT CHAR. IN DATA REG. PUT I/O REQUEST IN STATUS
READY = Ø ?
NO
YES
CLEAR I/O REQUEST
DECREMENT LENGTH CNTR
LEN. CNTR = Ø ?
NO
SEND RETURN CHAR.
RETURN TO MBASIC

```
 1:
 2:
 3:                   ;*********************************************************
 4:                   ;*
 5:                   ;*          CYDRIVER     BY JUSIN D. REDD  -BYU CAM LAB-
 6:                   ;*                             OCTOBER,1983
 7:                   ;*                       (ORIGINAL 6502 VERSION BY BRANDT C. REDD)
 8:                   ;*
 9:                   ;*  THIS PROGRAM TAKES A STRING FROM MBASIC THROUGH THE 'USR' FUNCTI
10:                   ;*  AND SENDS IT TO THE CY-512 6-AXIS STEPPER MOTOR CONTROLER.
11:                   ;*
12:                   ;*  COMMUNICATION IS THROUGH AN 'APPLE EXPANDER' PARALLEL COMMUNICAT
13:                   ;*  CARD MANUFACTURED BY ROBOTIC SYNERGY, INC.  THIS PROGRAM ASSUMES
14:                   ;*  THAT THE CARD IS PLACED IN SLOT 7, BUT MAY BE EASILY MODIFIED.
15:                   ;*
16:                   ;*  TO MODIFY FOR OTHER THAN SLOT 7, CHANGE LINES 30 AND 31 AS FOLLO
17:                   ;*  30:  STBASE: EQU    0E0X0   (WHERE X= SLOT# + 8)
18:                   ;*  31:  DTBASE: EQU    0E0X4   (WHERE X= SLOT# + 8)
19:                   ;*
20:                   ;*  THE DEF USRX STATEMENT MUST BE USED FROM MBASIC TO ENTER THIS
21:                   ;*  PROGRAM AT THE PROPER POINT FOR THE DESIRED AXIS
22:                   ;*
23:                   ;*********************************************************
24:                   ;
25:  C400                     ORG      0C400H          ;START ASSEMBLY AT LOCATION C400H
26:                   ;
27:                   ;******************************
28:                   ;*  SET-UP
29:                   ;******************************
30:                   ;
31:  C400             STRING: DS       2
32:  C402             DESC:   DS       2
33:  C404             LENGTH: DS       1
34:  C405             STAT:   DS       2
35:  C407             DATA:   DS       2
36:  E0F0 =           STBASE: EQU      0E0F0H          ;** CHANGE IF SLOT <> 7 **
37:  E0F4 =           DTBASE: EQU      0E0F4H          ;** CHANGE IF SLOT <> 7 **
38:                   ;
39:                   ;******************************
40:                   ;*  ENTRY POINTS
41:                   ;******************************
42:                   ;
43:  C409 CD57C4      CY1:    CALL     INIT            ;INITIALIZE
44:  C40C 0600                MVI      B,00H           ;OFFSET STAT REG VALUE FOR CY#1
45:  C40E 0E00                MVI      C,00H           ;OFFSET DATA REG VALUE FOR CY#1
46:  C410 CD74C4              CALL     SETUP           ;CALL SUB TO SETUP STAT AND DATA
47:  C413 C387C4              JMP      MAIN            ;JUMP TO MAIN PROGRAM
48:  C416 CD57C4      CY2:    CALL     INIT            ;INITIALIZE
49:  C419 0601                MVI      B,01H           ;OFFSET STAT REG VALUE FOR CY#2
50:  C41B 0E01                MVI      C,01H           ;OFFSET DATA REG VALUE FOR CY#2
51:  C41D CD74C4              CALL     SETUP           ;SUB TO SET UP STAT & DATA ADDRESSES
52:  C420 C387C4              JMP      MAIN            ;JUMP TO MAIN PROGRAM
53:  C423 CD57C4      CY3:    CALL     INIT            ;INITIALIZE
54:  C426 0602                MVI      B,02H           ;OFFSET STAT REG VALUE FOR CY#3
55:  C428 0E02                MVI      C,02H           ;OFFSET DATA REG VALUE FOR CY#3
56:  C42A CD74C4              CALL     SETUP           ;SET UP STAT & DATA REG ADDRESSES
57:  C42D C387C4              JMP      MAIN            ;JUMP TO MAIN PROGRAM
58:  C430 CD57C4      CY4:    CALL     INIT            ;INITIALIZE
59:  C433 0608                MVI      B,08H           ;OFFSET STAT REG VALUE FOR CY#4
60:  C435 0E08                MVI      C,08H           ;OFFSET DATA REG VALUE FOR CY#4
```

```
 10 REM ****************************************
 20 REM *
 30 REM *          LOADASM.BAS
 40 REM *              BY
 50 REM *          JUSTIN D. REDD     - BYU CAM LAB -
 60 REM *                               OCTOBER, 1983
 70 REM *  THIS PROGRAM CHECKS TO SEE IF COMM.HEX
 80 REM *  AND CYDRIVER.HEX HAVE BEEN LOADED INTO
 90 REM *  MEMORY.  IF THEY HAVE NOT THEN THE PROGRAM
100 REM*   CHAINS TO THE 'BLOAD' PROGRAM AND LOADS
110 REM*   THEM INTO MEMORY.
120 REM*
130 REM*   THE LOCATIONS C4F1H - C4F7H ARE USED TO
140 REM*   INDICATE PROGRAM LOADING STATUS.  LOCATIONS
150 REM*   C4F1 - C4F5H WILL CONTAIN THE ASCII CODES
160 REM*   FOR "VALID" IF DATA IS VALID AND LOCATIONS
170 REM*   C4F6H & C4F7H WILL CONTAIN ASCII "0", OR "1".
180 REM*   0 = PROGRAM NOT LOADED  1 = PROGRAM LOADED
190 REM*   C4F6H CORRESPONDS TO CYDRIVER.HEX
195 REM*   C4F7H CORRESPONDS TO COMM.HEX
200 REM*
210 REM*****************************************
220 REM
230 COMMON CALLER$,CLINE
240 COMMON PRGM$,SLINE,HFILE$
250 REM
260 REM *************************
270 REM * CHECK STATUS
280 REM *************************
290 REM
300 PRINT:INVERSE:PRINT "CHECKING FOR CYDRIVER.HEX AND COMM.HEX";:NORMAL:PRINT
310 MESS$=""
320 FOR CHAR = 0 TO 6
330 LOCATION = &HC4F1 + CHAR
340 CHAR$=CHR$(PEEK(LOCATION))
350 MESS$=MESS$ + CHAR$:CHAR$=""
360 NEXT CHAR
370 IF LEFT$(MESS$,5) < > "VALID" THEN GOTO 440
380 X$=RIGHT$(MESS$,2)
390 IF X$="10" THEN GOTO 640
400 IF X$="01" THEN GOTO 550
410 IF X$="11" THEN GOTO 730
420 GOTO 440
430 REM
440 REM *************************
450 REM * LOAD BOTH PROGRAMS
460 REM *************************
470 REM
480 PRINT:INVERSE:PRINT "LOADING CYDRIVER.HEX AT C400H";:NORMAL:PRINT
490 PRGM$="B:LOADASM.BAS":SLINE=510:HFILE$="B:CYDRIVER.HEX"
500 CHAIN "B:BLOAD.BAS",,ALL
510 PRINT:INVERSE:PRINT "LOADING COMM.HEX AT C500H";:NORMAL:PRINT
520 SLINE = 530:HFILE$="B:COMM.HEX":CHAIN "B:BLOAD.BAS",,ALL
530 GOTO 730
540 REM
550 REM *************************
```

```
540 REM ****************************
550 REM *  DO AS COMMANDED
560 REM *****************************
570 REM
574 MENU$="MENU"
580 IF CHOICE$ = "1" THEN CHAIN "INTERP.BAS"
590 IF CHOICE$ = "2" THEN CHAIN "CYEXEC.BAS"
600 IF CHOICE$ = "3" THEN CHAIN "LZERO.BAS",,ALL
610 IF CHOICE$ = "4" THEN CHAIN "MZERO.BAS"
615 IF CHOICE$ = "5" THEN CHAIN "LINEXEC.BAS",,ALL
620 IF CHOICE$ = "6" THEN HOME:END
```

```
 10 REM **************************************************
 20 REM *
 30 REM *  MENU.BAS  BY  JUSTIN D. REDD      - BYU CAM LAB -
 40 REM *                                   DECEMBER, 1983
 50 REM *
 60 REM *  THIS PROGRAM PROVIDES A SELF EXPLAINATORY MENU
 70 REM *  THAT CHAINS TO OTHER PROGRAMS TO CREATE AND
 80 REM *  EXECUTE COMMAND FILES FOR THE MINI LATHE AND
 90 REM *  MINI MILL.
100 REM*
110 REM**************************************************
120 REM
130 REM **********************************
140 REM * CHECK FOR CYDRIVER.HEX IN MEMORY
150 REM **********************************
160 REM
170 PRINT:INVERSE:PRINT "CHECKING FOR CYDRIVER.HEX";:NORMAL:PRINT
180 MESS$=""
190 FOR CHAR = 0 TO 6
200 LOCATION = &HC4F1 + CHAR
210 CHAR$=CHR$(PEEK(LOCATION))
220 MESS$=MESS$ + CHAR$:CHAR$= ""
230 NEXT CHAR
240 IF LEFT$(MESS$,5) <> "VALID" THEN GOTO 270
250 X$=MID$(MESS$,6,1)
260 IF X$="1" THEN GOTO 320
270 PRINT:INVERSE:PRINT "LOADING CYDRIVER.HEX AT C400H";:NORMAL:PRINT
280 PRGM$="MENU.BAS":SLINE=320:HFILE$="CYDRIVER.HEX"
290 CALLER$="XXXX":CLINE=999
310 CHAIN "BLOAD.BAS",10,ALL
315 CLEAR,&HC400
320 DEF USR1=&HC409:CY1=&HC409
330 DEF USR2=&HC416:CY2=&HC416
340 DEF USR3=&HC423:CY3=&HC423
350 REM
360 REM *****************************
370 REM *  PRINT MENU
380 REM *****************************
390 REM
400 HOME:PRINT "    MINI-MACHINE PROGRAMMING MENU":PRINT
410 PRINT"           - BYU CAM LAB -":PRINT
420 PRINT"========================================"
430 PRINT:PRINT:PRINT "1) TRANSLATE AN RS274 TEXT FILE"
440 PRINT:PRINT"2) EXECUTE A TRANSLATED FILE"
450 PRINT:PRINT"3) ZERO LATHE"
460 PRINT:PRINT"4) ZERO MILL"
465 PRINT:PRINT "5) LINE BY LINE MANUAL EXECUTER"
470 PRINT:PRINT"6) QUIT"
480 PRINT:PRINT:PRINT "     SELECT ONE ==> ";
490 CHOICE$=INKEY$ : IF LEN(CHOICE$) = 0 THEN GOTO 490
500 VVP=VPOS(X):PRINT CHOICE$
510 IF ASC(CHOICE$)<49 OR ASC(CHOICE$)>54 THEN PRINT CHR$(7):INVERSE:PRINT "CHOO
SE 1,2,3,4,5, OR 6 ONLY";:NORMAL:VTAB (VVP):HTAB (21
) : GOTO 490
520 PRINT:PRINT"                                       "
530 REM
```

APPENDIX J

Various CNC Programs for the Lathe and Milling Machine

2) INTERFRETING THE COMMAND FILE

To interpret and run the command file written with ED.COM programs written in MBASIC are used. MBASIC must be loaded into memory from the CP/M operating system. To load MBASIC type 'MBASIC /M:&HC400'.

Once MBASIC is loaded into memory all other necessary programs can be run from the master program called 'MENU.BAS'. To run this program from MBASIC type 'RUN "MENU"'.

To interpret a file select option '1' from the menu and follow the instructions.

3) EXECUTING THE PROGRAM

To execute the interpreted program select '2' on the menu and follow the instructions. Remember to turn on the 'blue box' first. Moving the axis' to their zero positions is accomplished by selecting the appropriate option from the menu. To return to the CP/M system from MBASIC type 'SYSTEM'.

displaying a header and a prompt for motor 'A' which indicates the motor labeled #1 on the blue box. All commands entered will be sent to motor #1 when <return> is pushed. (A list of the commands that are recognized by the blue box appears in the CY512 documentation booklet.) Multiple commands may be entered on one line by separating each command with a comma. The following is an example of a command line that sets the rate, slope, factor, number of steps, direction, and finally tells the motor to 'GO':

```
A>R 250,S 1,F 1,N 1000,+,G
```

To address a different motor type a slash (/) followed by the motor symbol. (Motor symbols are as follows: 'A'=1, 'B'=2, 'C'=3, '2A'=4, '2B'=5, and '2C'=6) To exit the program type '/Q'.

B. PROGRAM CONTROL

Programming a sequence of moves into the mini-machines involes three steps. These include creating a text file containing the mini-machine instructions using the CP/M system editor (ED.COM), interpreting the text file to 'blue box' compatible commands using the MBASIC INTERP.BAS program, and running the program using the MBASIC CYEXEC.BAS program.

1) CREATING THE N/C MACHINE CODE FILE

NOTE: Some knowlege of the CP/M system editor ED.COM is necessary to use the mini-machines under program control. The use of ED.COM is detailed in the Microsoft Softcard Manual, Vol 1.

The first step in programming the mini-machines is to ~~enter~~ save the program as a text file on the disk. The file may have any name, but it should have the extention .RSC. Command lines consist of the line number, X,Y, and Z distances, and the Feedrate. All command lines must end with a dollar sign ($). After the dollar sign any comments may be inserted. The file must end with a line containing a single dollar sign and nothing else. Details of each of the parameters of the command line are listed below:

LINE # - must contain 'N' followed by 3 digits. (Ex. N005)
X - contains an 'X' followed by distance in inches (Ex. X-10.125)
Y - contains a 'Y' followed by Y-distance in inches (Ex. Y+2.35)
Z - contains a 'Z' followed by Z-distance in inches (Ex. Z-1.00)
F - contains a 'F' followed by feedrate in in./min. (Ex. F55.25)

Spacing between parameters is not critical and can be used to make the program listing more readable. Each parameter does have a maximum number of digits a list of which follows:

Nxxx - 3 digits must be included in the line number parameter
Xxx.xxx - maximum of 2 digits to left and 3 to right of decimal
Yxx.xxx - same as above
Zxx.xxx - same as above
Fxxx.xx - maximum of 3 digits to left and 2 to right of decimal

Following is an example of a sample program:

```
N001  X1.00    Y0.00    Z0.00    F100    $ X POS. 1 IN. AT 100 IN/MIN
N002  X0.00    Y5       Z0.00    F50.5   $ Y POS. 5 IN. AT 50.5 IN/MIN
N003  X0.00    Y0.00    Z12.125  F4      $ Z POS. 12.125 INCHES
N004  X-1.00   Y-5      Z-12.125 F100    $ BACK TO START
$
```

3) THE LIMIT SWITCHES:

The limit switches are connected to the row of white sockets labeled 'switches' on the motor control box. A four conductor cable connects box with the actual switches. Each of the white switch sockets should have pins 4 and 6 wired together. The limit switch corresponding a given axis should be wired to pin 2 of the white socket. Pin 4 of the white socket is a +5 Volt output and is wired to the common terminal on all the limit switches. Following is a listing of cable wire colors with their corresponding axis' and socket pins:

Cable Wire Color	Axis #	'Blue Box' Pin #	Mini-Machine Pin #
Red	1	2, Socket 1	1
Green	2	2, Socket 2	2
White	3	2, Socket 3	3
Black	Common	4, Any Socket	6

C. THE STEPPER MOTORS:

The stepper motors connect to the stepper motor controller box with cables and plugs/sockets. See part B.2 above wiring details.

II. SOFTWARE

A number of programs have been written for mini-machine and stepper motor control. A list of these programs and some useful utility programs needed follows:

Program Name	Purpose
ED.COM	CP/M Utility to create text files(see Softcard V1)
SMARTCY.COM	Manual stepper motor control program by M. Smart
MBASIC.COM	Microsoft Basic
PIP.COM	CP/M file transfer utility(see Softcard Manual V1)
MENU.BAS	Master menu for use with machine control programs
LOADASM.BAS	Loads in necessary assembly language subroutines
BLOAD.BAS	Loads machine langruage from .HEX files
INTERP.BAS	Interprets NC coded text files to run mini-machines
CYEXEC.BAS	Executes interpreted machine control files
MZERO.BAS	Zero's all axis' on the mini-mill
LZERO.BAS	Zero's all axis' on the mini-lathe
CYDRIVER.HEX	Machine language routine to communicate with 'blue box'
COMM.HEX	Machine language routine to use serial comm. card

III. RUNNING THE MACHINES:

There are two ways of running the mini-machines. Manual control refers to giving commands directly to the stepper motors one at a time. Program control refers to executing stepper motors commands directly from program control.

A. MANUAL CONTROL:

To manually control the individual motors, get into the CP/M system environment (by booting up from disk or by typing 'SYSTEM' from MBASIC) and type 'SMARTCY'. The computer will respond by

MINI-LAB LATHE & MILL OPERATING INSTRUCTIONS

I. SET-UP

The mini machine control system consists of three systems or stages that must all be connected together properly for operation of the mini-machines from the APPLE computer. These are the APPLE computer itself, the stepper motor control box or 'blue box', and the stepper motors.

A. THE APPLE COMPUTER:

The APPLE computer must include some periferals which plug into the slots at the rear of the computer. In some cases slot placement is critical. Following is a list of periferal cards and the slots they should be plugged into:

SLOT 0	Language RAM Card
SLOT 1	Printer (if used)
SLOT 2	Serial RS232 Card (if used)
SLOT 3	
SLOT 4	Floppy Disk Drives (w/ CORVUS)
SLOT 5	Z-80 Microsoft Softcard
SLOT 6	CORVUS or Floppy Disk Drives
SLOT 7	'Blue Box' Apple Bus Expander

Care should be taken to install the cards properly into their correct places.

B. THE SIX AXIS STEPPER MOTOR CONTROL BOX

The stepper motor control box or 'blue box' as it is commonly called has three important connection areas. These are the parallel port that goes to the APPLE, the motor connection sockets, and the limit switch connection sockets.

1) PARALLEL COMPUTER INTERFACE:

The parallel port on the 'blue box' is located at the bottom center position. This must be connected with a ribbon cable to the apple bus expander card which should be located in slot 7 of the APPLE.

2) THE STEPPER MOTORS:

The six stepper motor connection sockets are located on the bottom row of the 'blue box' and numbered 1 - 6 starting on the right hand side. These must be connected to the stepper motors themselves with six conductor cables. The standard color coding of the cables and the motor wires, along with their corresponding pins in the plugs and sockets connecting them follows:

Socket pin #	Cable Wire Color	Motor Wire Color	Function
1	Red	Red	Motor Phase #1
2	Black	Black	R-Series
3	Orange	Red/White	Motor Phase #2
4	Blue	Green/White	Motor Phase #4
5	Green	Green	Motor Phase #3
6	White	White	R-Series

APPENDIX I

Operating Instructions for the Miniature Lathe and Milling Machine

```
C575 FEFF                   CPI     0FFH            ;SEE IF IT'S OVERFLOWING
C577 CA7DC5                 JZ      RDONE           ;IF SO, GOTO RDONE
C57A F25BC5                 JP      WAIT2           ;LOOP BACK FOR NEXT CHAR
C57D 21A0E0      RDONE:     LXI     H,STAT          ;LOAD HL WITH STAT ADDRESS
C580 3655                   MVI     M,055H          ;CLEAR RS-232 CTS LINE (DISABLE RECIEVE
C582 05                     DCR     B               ;DECREMENT CHAR. CNTR TO TRUE VALUE
C583 78                     MOV     A,B             ;PUT STRING LENGTH IN A
C584 2A00C5                 LHLD    DESC            ;LOAD HL WITH STR DESC ADDRESS
C587 77                     MOV     M,A             ;SAVE STRING LENGTH TO 1ST DESC. BYTE
C588 23                     INX     H               ;INCREMENT HL TO 2ND BYTE OF DESCRIPTOR
C589 EB                     XCHG                    ;CHANGE DE WITH HL
C58A 2A02C5                 LHLD    STRING          ;PUT STRING ADDRESS IN HL
C58D EB                     XCHG                    ;CHANGE DE WITH HL
C58E 73                     MOV     M,E             ;SAVE L.O.B. OF STR ADDRESS TO STR DES
C58F 23                     INX     H               ;INCREMENT HL TO 3RD BYTE OF DESCRIPTO
C590 72                     MOV     M,D             ;SAVE H.O.B. OF STR ADDRESS TO STR DES
C591 2A00C5                 LHLD    DESC            ;LOAD HL WITH DESCRIPTOR ADDRESS
C594 EB                     XCHG                    ;PUT DESC ADDRESS IN DE
C595 3E03                   MVI     A,03H           ;PUT STRING CODE IN ACCUMULATOR
C597 C39AC5                 JMP     DONE            ;GOTO DONE
                 ;
                 ;********************************
                 ;* DONE
                 ;********************************
                 ;
C59A E1          DONE:      POP     H               ;PULL OLD SP OFF NEW STACK
C59B F9                     SPHL                    ;RESTORE OLD STACK
C59C C9                     RET                     ;RETURN TO MBASIC
C4F1                        ORG     0C4F1H          ;MOVE LOCATION COUNTER
C4F1 56414C4944             DB      'VALID'         ;TELL BASIC THAT PROGRAM IS LOADED
C4F7                        ORG     0C4F7H          ;MOVE LOCATION COUNTER AGAIN
C4F7 31                     DB      '1'             ;*
C4F8                        END
```

```
C51E 6F                    MOV     L,A             ;LOAD L REG WITH L.O.B. OF STR ADDRESS
C51F 13                    INX     D               ;INC DE TO POINT TO STR ADDRESS H.O.B.
C520 1A                    LDAX    D               ;LOAD A WITH H.O.B. OF STR ADDRESS
C521 67                    MOV     H,A             ;LOAD H REG WITH H.O.B.
C522 2202C5                SHLD    STRING          ;SAVE STRING ADDRESS
C525 78                    MOV     A,B             ;MOVE STRING LENGTH TO A
C526 EB                    XCHG                    ;PUT STR ADDRESS IN DE
C527 C1                    POP     B               ;POP INIT RETURN ADDRESS OFF OLD STACK
C528 210000                LXI     H,0000H         ;CLEAR HL
C52B 39                    DAD     SP              ;ADD STACK POINTER (SP) TO HL
C52C 3100C6                LXI     SP,0C600H       ;INIT NEW STACK POINTER AT C600H
C52F E5                    PUSH    H               ;PUSH OLD SP ONTO NEW STACK
C530 C5                    PUSH    B               ;PUSH INIT RETURN ADDRESS ONTO NEW STAC
C531 C9                    RET                     ;RETURN FROM SUBROUTINE
                   ;
                   ;*********************************
                   ;* SEND ROUTINE
                   ;*********************************
                   ;
C532 2A00C5        SEND:   LHLD    DESC            ;LOAD HL WITH STR DESCR. ADDRESS
C535 4E                    MOV     C,M             ;MOVE STRING LENGTH TO C
C536 2A02C5                LHLD    STRING          ;LOAD HL WITH STRING STARTING ADDRESS
C539 EB                    XCHG                    ;EXCHANGE HL AND DE
C53A 0601                  MVI     B,01H           ;INITIALIZE B AS CHAR. CNTR
C53C 21A0E0        WAIT1:  LXI     H,STAT          ;LOAD HL WITH ADDRESS OF STATUS
C53F 7E                    MOV     A,M             ;LOAD A WITH STATUS
C540 E602                  ANI     TRDY            ;MASK OUT TRANS. READY BIT
C542 FE02                  CPI     TRDY            ;IS READY BIT SET?
C544 C23CC5                JNZ     WAIT1           ;IF NOT, WAIT AGAIN ...
C547 1A                    LDAX    D               ;LOAD ACC WITH CHAR.
C548 32A1E0                STA     DATA            ;SEND CHAR. OUT
C54B 79                    MOV     A,C             ;PUT STRING LENGTH IN A
C54C B8                    CMP     B               ;COMPARE WITH CHAR. CNTR
C54D CA9AC5                JZ      DONE            ;ALL CHAR.S SENT. GOTO DONE
C550 13                    INX     D               ;INCREMENT CHAR. POINTER
C551 04                    INR     B               ;INCREMENT CHAR. COUNTER
C552 C33CC5                JMP     WAIT1           ;LOOP BACK FOR NEXT CHAR.
                   ;
                   ;
                   ;*********************************
                   ;* RECIEVE
                   ;*********************************
                   ;
C555 0601          REC:    MVI     B,01H           ;INITIALIZE CHAR. COUNTER
C557 2A02C5                LHLD    STRING          ;LOAD HL WITH STRING ADDRESS
C55A EB                    XCHG                    ;PUT STRING ADDRESS IN DE
C55B 21A0E0        WAIT2:  LXI     H,STAT          ;LOAD HL WITH STAT ADDRESS
C55E 7E                    MOV     A,M             ;LOAD ACC WITH STATUS
C55F E601                  ANI     DRDY            ;MASK OUT DRDY BIT
C561 FE01                  CPI     DRDY            ;SEE IF BIT IS SET
C563 C25BC5                JNZ     WAIT2           ;WAIT UNTILL BIT IS SET
C566 21A1E0        GETIT:  LXI     H,DATA          ;LOAD HL WITH DATA ADDRESS
C569 7E                    MOV     A,M             ;READ IN THE NEXT CHARACTER
C56A E67F                  ANI     07FH            ;GET RID OF HIGH BIT
C56C FE0A                  CPI     0AH             ;SEE IF CHAR WAS A LINE FEED
C56E CA7DC5                JZ      RDONE           ;IF IT WAS THEN GOTO RDONE
C571 12                    STAX    D               ;STORE ACC TO STRING STORAGE LOCATION
C572 13                    INX     D               ;INCREMENT CHAR. STORAGE POINTER
C573 04                    INR     B               ;INCREMENT CHAR. COUNTER
C574 78                    MOV     A,B             ;PUT CHAR CNTR IN A



C575 FEFF                  CPI     0FFH            ;SEE IF IT'S OVERFLOWING
```

```


               ;******************************************************
               ;*
               ;*  THIS PROGRAM IS CALLED FROM MBASIC TO SEND OR
               ;*  RECIEVE CHARACTERS FROM THE RS232 COMMUNICATIONS
               ;*  CARD.
               ;*       THE FORMATT FOR CALLING THE ROUTINE FROM
               ;*  MBASIC IS AS FOLLOWS:
               ;*     X$=USR1('STRING') TO SEND 'STRING'
               ;*     X$=USR2 TO RECIEVE A STRING
               ;*      (DEF USR1=SSTART, DEF USR2=RSTART)
               ;*
               ;*  PROGRAM WRITTEN BY: JUSTIN D. REDD  -BYU CAM LAB-
               ;*                      AUGUST 1983
               ;*
               ;******************************************************
               ;
C500                   ORG     0C500H          ;START ASSEMBLY AT LOCATION C500H
               ;
               ;************************************
               ;* I. INITIALIZATION
               ;************************************
               ;
E0A0 =         STAT    EQU     0E0A0H
E0A1 =         DATA    EQU     0E0A1H          ; ADDRESSES OF RS232 CARD BUFFERS
               ;*** STAT AND DATA SET FOR APPLE SLOT#2.
               ;*** FOR OTHER SLOTS: STAT=C0X0H & DATA=C0X1H   X=8+SLOT#
               ;***
0001 =         DRDY    EQU     01H             ; DATA READY CODE IN STATUS REG.
0002 =         TRDY    EQU     02H             ; TRANSMIT READY CODE IN STATUS REG.
C500           DESC:   DS      2               ;RESERVE 2 BYTES FOR STRING DESCRIPTOR
C502           STRING: DS      2               ;   "    "    "   FOR STRING ADDRESS
C504           LCNTR:  DS      1               ;RESERVE 1 BYTE FOR LOOP COUNTER
               ;
               ;
               ;***********************************
               ;* II. MAIN PROGRAM
               ;***********************************
               ;
               ;**** SEND OR RECIEVE ? ****
               ;
C505 CD16C5    SSTART: CALL    INIT            ;INITIALIZE SUBROUTINE
C508 C332C5            JMP     SEND            ;JUMP TO SEND ROUTINE
               ;
C50B CD16C5    RSTART: CALL    INIT            ;INITIALIZE SUBROUTINE
C50E 21A0E0            LXI     H,STAT          ;LOAD HL WITH STAT (COMMAND REG) ADDRES
C511 3615              MVI     M,015H          ;SET RS-232 CTS LINE (ENABLE IBM TRANS
C513 C355C5            JMP     REC             ;JUMP TO RECIEVE ROUTINE
               ;
               ;********************************
               ;*  INITIALIZE SUBROUTINE
               ;********************************
               ;
C516 47        INIT:   MOV     B,A             ;MOVE STRING LENGTH TO B
C517 EB                XCHG                    ;EXCHANGE DE AND HL
C518 2200C5            SHLD    DESC            ;SAVE STR DESCRIPTOR ADDRESS
C51B EB                XCHG                    ;RESTORE DE AND HL
C51C 13                INX     D               ;INCREMENT DE TO POINT TO STR ADDRESS
C51D 1A                LDAX    D               ;LOAD A WITH 1ST BYTE OF STR ADDRESS
```

```
C48E 3A04C4                 LDA     LENGTH          ;LOAD ACC WITH STRING LENGTH
C491 3D                     DCR     A               ;DECREMENT LENGTH
C492 3204C4                 STA     LENGTH          ;STORE DECREMENTED LENGTH
C495 CACDC4                 JZ      DONE            ;IF LENGTH = 0 THEN WE'RE DONE
C498 2A00C4                 LHLD    STRING          ;LOAD HL WITH STRING ADDRESS
C49B 23                     INX     H               ;INCREMENT STRING ADDRESS
C49C 2200C4                 SHLD    STRING          ;STORE INCREMENTED STRING VALUE
C49F C387C4                 JMP     MAIN            ;GO BACK TO BEGINNING OF MAIN
                    ;
                    ;********************************
                    ;* SEND
                    ;********************************
                    ;
C4A2 E67F           SEND:   ANI     07FH            ;CLEAR BIT #7
C4A4 FE2C                   CPI     02CH            ;COMPARE ACC WITH ','
C4A6 C2ABC4                 JNZ     SCONT1          ;IF ACC < > ',' THEN GOTO SCONT1
C4A9 3E0D                   MVI     A,0DH           ;CHANGE ACC TO 'RETURN'
C4AB 2A05C4         SCONT1: LHLD    STAT            ;LOAD HL WITH STAT ADDRESS
C4AE 47                     MOV     B,A             ;PUT CHAR IN B
C4AF 7E             SCONT2: MOV     A,M             ;LOAD ACC WITH STAT
C4B0 E604                   ANI     04H             ;MASK OUT READY BIT
C4B2 FE04                   CPI     04H             ;COMPARE ACC WITH 04H
C4B4 C2AFC4                 JNZ     SCONT2          ;GO BACK AND WAIT TILL READY = 1
C4B7 2A07C4                 LHLD    DATA            ;LOAD DATA ADDRESS INTO HL
C4BA 70                     MOV     M,B             ;PUT CHAR IN DATA REGISTER
C4BB 3E41                   MVI     A,041H          ;LOAD ACC WITH I/O REQUEST WORD
C4BD 2A05C4                 LHLD    STAT            ;LOAD HL WITH STAT ADDRESS
C4C0 77                     MOV     M,A             ;SEND I/O REQUEST
C4C1 7E             SCONT3: MOV     A,M             ;PUT STAT IN ACC
C4C2 E604                   ANI     04H             ;MASK OUT READY BIT
C4C4 FE04                   CPI     04H             ;COMPARE ACC WITH 04H
C4C6 CAC1C4                 JZ      SCONT3          ;WAIT TILL READY = 0
C4C9 3E40                   MVI     A,040H          ;LOAD ACC WITH I/O REQ CLEAR WORD
C4CB 77                     MOV     M,A             ;SEND I/O REQ CLEAR WORD
C4CC C9                     RET                     ;RETURN FROM SUBROUTINE
                    ;
                    ;********************************
                    ;* DONE
                    ;********************************
                    ;
C4CD 2A05C4         DONE:   LHLD    STAT            ;LOAD HL WITH STAT ADDRESS
C4D0 7E                     MOV     A,M             ;PUT STATUS IN ACC
C4D1 E604                   ANI     04H             ;MASK OUT READY BIT
C4D3 FE04                   CPI     04H             ;COMPARE ACC WITH 04H
C4D5 C2CDC4                 JNZ     DONE            ;GO BACK AND WAIT TILL READY = 1
C4D8 2A07C4                 LHLD    DATA            ;LOAD DATA ADDRESS INTO HL
C4DB 360D                   MVI     M,0DH           ;SEND RETURN CHAR
C4DD 3E41                   MVI     A,041H          ;LOAD ACC WITH I/O REQUEST WORD
C4DF 2A05C4                 LHLD    STAT            ;LOAD HL WITH STAT ADDRESS
C4E2 77                     MOV     M,A             ;SEND I/O REQUEST
C4E3 7E             DCONT1: MOV     A,M             ;PUT STAT IN ACC
C4E4 E604                   ANI     04H             ;MASK OUT READY BIT
C4E6 FE04                   CPI     04H             ;COMPARE ACC WITH 04H
C4E8 CAE3C4                 JZ      DCONT1          ;WAIT TILL READY = 0
C4EB 3E40                   MVI     A,040H          ;LOAD ACC WITH I/O REQ WORD
C4ED 77                     MOV     M,A             ;SEND I/O REQ CLEAR WORD
C4EE E1                     POP     H               ;POP OLD STACK POINTER OFF NEW STACK
C4EF F9                     SPHL                    ;RESTORE OLD STACK
C4F0 C9                     RET
C4F1 56414C4944             DB      'VALID1'        ;MESSAGE TO TELL BASIC PROGRAM IS LOA
```

```
C437 CD74C4          CALL    SETUP           ;SETUP STAT & DATA REG ADDRESSES
C43A C387C4          JMP     MAIN            ;JUMP TO MAIN PROGRAM
C43D CD57C4  CY5:    CALL    INIT            ;INITIALIZE
C440 0609            MVI     B,09H           ;OFFSET STAT REG VALUE FOR CY#5
C442 0E09            MVI     C,09H           ;OFFSET DATA REG VALUE FOR CY#5
C444 CD74C4          CALL    SETUP           ;SETUP STAT & DATA REG ADDRESSES
C447 C387C4          JMP     MAIN            ;JUMP TO MAIN PROGRAM
C44A CD57C4  CY6:    CALL    INIT            ;INITIALIZE
C44D 060A            MVI     B,0AH           ;OFFSET STAT REG VALUE FOR CY#6
C44F 0E0A            MVI     C,0AH           ;OFFSET DATA REG VALUE FOR CY#6
C451 CD74C4          CALL    SETUP           ;SETUP STAT & DATA REG ADDRESSES
C454 C387C4          JMP     MAIN            ;JUMP TO MAIN PROGRAM
             ;
             ;********************************
             ;* INITIALIZE SUBROUTINE
             ;********************************
             ;
C457 EB      INIT:   XCHG                    ;SWITCH DE AND HL
C458 2202C4          SHLD    DESC            ;SAVE STRING DESCRIPTOR ADDRESS
C45B 7E              MOV     A,M             ;PUT STRING LENGTH IN ACC
C45C 3204C4          STA     LENGTH          ;STORE STRING LENGTH
C45F EB              XCHG                    ;RESTORE REGISTERS
C460 13              INX     D               ;INCREMENT DE TO POINT TO STRING ADD
C461 1A              LDAX    D               ;LOAD ACC WITH L.O.B. OF STR ADDRESS
C462 6F              MOV     L,A             ;LOAD L.O.B. OF STR ADDRESS INTO L
C463 13              INX     D               ;INCREMENT DE TO POINT TO H.O.B
C464 1A              LDAX    D               ;LOAD ACC WITH H.O.B. OF STR ADDRESS
C465 67              MOV     H,A             ;LOAD L.O.B. OF STR ADDRESS INTO H
C466 2200C4          SHLD    STRING          ;SAVE STRING ADDRESS
C469 C1              POP     B               ;POP INIT RETURN ADDRESS OFF OLD STAC
C46A 210000          LXI     H,0000H         ;CLEAR HL TO 0000
C46D 39              DAD     SP              ;ADD STACK POINTER (SP) TO HL
C46E 3100C6          LXI     SP,0C600H       ;SET STACK POINTER TO NEW STACK AT C
C471 E5              PUSH    H               ;PUSH OLD STACK LOCATION ONTO NEW ST
C472 C5              PUSH    B               ;PUSH INIT RETURN ADDRESS ONTO NEW ST
C473 C9              RET                     ;RETURN FROM SUBROUTINE
             ;
             ;********************************
             ;* SETUP DATA & CNTRL ADDRESSES
             ;********************************
             ;
C474 21F0E0  SETUP:  LXI     H,STBASE        ;LOAD HL WITH STAT BASE ADDRESS
C477 78              MOV     A,B             ;PUT STAT OFFSET FOR CY# IN ACC
C478 85              ADD     L               ;ADD L.O.B. OF STAT BASE ADDRESS
C479 6F              MOV     L,A             ;PUT ADJUSTED L.O.B. BACK IN L
C47A 2205C4          SHLD    STAT            ;SAVE STAT REG ADDRESS TO STAT
C47D 21F4E0          LXI     H,DTBASE        ;LOAD HL WITH DATA BASE ADDRESS
C480 79              MOV     A,C             ;PUT DATA OFFSET FOR CY# IN ACC
C481 85              ADD     L               ;ADD L.O.B. OF DATA BASE ADDRESS
C482 6F              MOV     L,A             ;PUT ADJUSTED L.O.B. BACK IN L
C483 2207C4          SHLD    DATA            ;SAVE DATA REG ADDRESS TO DATA
C486 C9              RET                     ;RETURN FROM SUBROUTINE
             ;
             ;********************************
             ;* MAIN PROGRAM
             ;********************************
             ;
C487 2A00C4  MAIN:   LHLD    STRING          ;LOAD HL WITH STRING ADDRESS
C48A 7E              MOV     A,M             ;LOAD ACC WITH FIRST CHAR
C48B CDA2C4          CALL    SEND            ;SEND CHARACTER TO CY'S
```

```
560 REM * LOAD CYDRIVER.HEX ONLY
570 REM *************************
580 REM
590 PRINT:INVERSE:PRINT "LOADING CYDRIVER.HEX AT C400H";:NORMAL:PRINT
600 PRGM$="B:LOADASM.BAS":SLINE=620:HFILE$="B:CYDRIVER.HEX"
610 CHAIN "B:BLOAD.BAS",,ALL
620 GOTO 730
630 REM
640 REM *************************
650 REM * LOAD COMM.HEX ONLY
660 REM *************************
670 REM
680 PRINT:INVERSE:PRINT "LOADING COMM.HEX AT C500H";:NORMAL:PRINT
690 PRGM$="B:LOADASM.BAS":SLINE=710:HFILE$="B:COMM.HEX"
700 CHAIN "B:BLOAD.BAS"
710 GOTO 730
720 REM
730 REM ************************
740 REM * CHAIN BACK
750 REM ************************
760 REM
820 DEF USR1=&HC409
830 DEF USR2=&HC416
840 DEF USR3=&HC423
850 DEF USR4=&HC430
860 DEF USR5=&HC43D
870 DEF USR6=&HC44A
880 DEF USR7=&HC505
890 DEF USR8=&HC50B
900 CHAIN CALLER$,CLINE,ALL
910 END
```

```
10 REM **********************************
20 REM *
30 REM *      BLOAD.BAS
40 REM *         BY
50 REM *    JUSTIN D. REDD            - BYU CAM LAB
60 REM *
70 REM * PROGRAM TO LOAD A .HEX FILE
80 REM * INTO MEMORY FROM MBASIC
90 REM *
100 REM * OPERATION: THIS PROGRAM WAS WRITTEN
110 REM *  TO BE CHAINED TO, USING THE 'COMMON'
120 REM *  STATEMENT TO DECLARE THE FOLLOWING
130 REM *  VARIABLES: PRGM$=PROGRAM TO CHAIN
140 REM*             TO AFTER LOADING .HEX FILE
150 REM*             SLINE=STARTING LINE IN PRGM$
160 REM*             HFILE$=.HEX FILE NAME
170 REM*
180 REM***********************************
190 REM
200 COMMON PRGM$,HFILE$,SLINE,CLINE,CALLER$
210 REM
220 REM ***************************
230 REM *    INITIALIZE           *
240 REM ***************************
250 REM
260 OPEN"I",#1,HFILE$
270 REM
280 REM ***************************
290 REM *    MAIN PROGRAM         *
300 REM ***************************
310 REM
320 GOSUB 360
330 GOSUB 470
340 GOTO 320
350 REM
360 REM ***************************
370 REM *    READ LINE S/R        *
380 REM ***************************
390 REM
400 INPUT#1,HLINE$
410 HBYTES$="&H" + MID$(HLINE$,2,2)
420 HADDRESS$="&H" + MID$(HLINE$,4,4)
430 BYTES=VAL(HBYTES$):ADDRESS=VAL(HADDRESS$)
440 IF BYTES=0 AND ADDRESS=0 THEN HOME:CLOSE:PRINT "PROGRAM LOADED":CHAIN PRGM$.
SLINE,ALL
450 RETURN
460 REM
470 REM ***************************
480 REM *    POKE BYTES S/R       *
490 REM ***************************
500 FOR I = 1 TO BYTES
510 LOCATION=ADDRESS + (I - 1)
520 CODE$="&H" + MID$(HLINE$,(8 + (I * 2)),2)
530 CODE=VAL(CODE$)
540 POKE LOCATION,CODE
550 NEXT I
```

```
560 RETURN
```

```
10 REM *****************************************************
20 REM *
30 REM *      INTERP.BAS        BY JUSTIN D. REDD
40 REM *                           - BYU CAM LAB -
50 REM *  CNC - CY512 TRANSLATOR   NOVEMBER, 1983
60 REM *
70 REM *  THIS PROGRAM READS RS274 STANDARD NUMERICAL CONTROL
80 REM *  CODES FROM A TEXT FILE AND TRANSLATES THEM TO
90 REM *  COMMANDS FOR THE CY512 STEPPER MOTER CONTROLLER.
100 REM*  THE RESULTING CY512 COMMANDS ARE STORED IN A TEXT
110 REM*  FILE OF THE SAME NAME WITH THE SUFFIX OF *.CYC
120 REM*
130 REM******************************************************
140 REM
145 COMMON MENU$
146 REM
147 REM
150 HOME:PRINT "RS274 - CY512  INTERPRETER             - BYU CAM LAB -"
160 PRINT:PRINT"----------------------------------------------------------------
----------------":PRINT:PRINT:PRINT
170 REM
180 REM ******************************
190 REM * OPEN FILE AND DIMENTION ARRAYS
200 REM ******************************
210 REM
220 INPUT "INTERPRET WHAT RS274 FILE ";RS274$
230 TEST$=RIGHT$ ( RS274$,4 )
240 IF LEFT$( TEST$,1 ) = "." THEN GOTO 255
250 RS274$ = RS274$ + ".RSC"
255 IF MID$(RS274$,2,1) = ":" THEN LLL = 14 ELSE LLL = 12
260 IF LEN(RS274$)>LLL THEN PRINT:PRINT "FILENAME TOO LONG!":PRINT:GOTO 220
265 ON ERROR GOTO 2181
270 OPEN"I",#1,RS274$
280 P=INSTR(RS274$,".")
290 CY512$=MID$(RS274$,1,P-1) + ".CYC"
300 OPEN"O",#2,CY512$
305 ON ERROR GOTO 0
310 DIM CYMOVE$(100)
320 DIM SLINE$(100)
330 NLINE = 0
340 REM ******************************
350 REM * INPUT LINES AND SEPARATE
360 REM ******************************
370 REM
380 FOR LINES = 1 TO 100
390 INPUT #1,SLINE$(LINES)
400 IF SLINE$(LINES) = "$" THEN LINES = LINES + 1 : GOTO 420
410 NEXT LINES
420 FOR I = 1 TO (LINES - 1)
430 XFLAG = 0 : YFLAG = 0 : ZFLAG = 0
440 NLINE = NLINE + 1
450 PRINT ".";
460 SLINE$=SLINE$(I)
470 N=INSTR(SLINE$,"N") : X=INSTR(SLINE$,"X") : Y=INSTR(SLINE$,"Y")
480 Z=INSTR(SLINE$,"Z") : F=INSTR(SLINE$,"F") : ENDLINE=INSTR(SLINE$,"$")
490 IF N=0 AND X=0 AND Y=0 AND Z=0 AND F=0 AND ENDLINE <> 0 THEN GOTO 2200
```

```
500 IF N=0 OR F=0 OR ENDLINE=0 THEN GOTO 1800
510 IF X=0 THEN X=CINT((N+Y)/2) : XFLAG = 1
520 IF Z=0 THEN Z=CINT((Y+F)/2) : ZFLAG = 1
530 IF Y=0 THEN Y=CINT((X+Z)/2) : YFLAG = 1
540 IF N>X OR N>Y OR N>Z OR N>F OR N>ENDLINE THEN GOTO 1670
550 IF X>Y OR X>Z OR X>F OR X>ENDLINE THEN GOTO 1670
560 IF Y>Z OR Y>F OR Y>ENDLINE THEN GOTO 1670
570 IF Z>F OR Z>ENDLINE THEN GOTO 1670
580 IF F>ENDLINE THEN GOTO 1670
590 REM
600 REM ************* SEPARATE PARAMETERS ****************
610 REM
620 IF XFLAG = 1 THEN X$="00.000" : GOTO 680
630 IF YFLAG = 0 THEN X$ = MID$(SLINE$,X+1,Y-(X+1)): GOTO 660
640 IF YFLAG = 1 AND ZFLAG = 0 THEN X$=MID$(SLINE$,X+1,Z-(X+1)) : GOTO 660
650 IF YFLAG = 1 AND ZFLAG = 1 THEN X$=MID$(SLINE$,X+1,F-(X+1))
660 PARAMETER$=X$ : GOSUB 810
670 X$=PARAMETER$
680 IF YFLAG = 1 THEN Y$="00.000" : GOTO 730
690 IF ZFLAG = 0 THEN Y$=MID$(SLINE$,Y+1,Z-(Y+1)): GOTO 710
700 IF ZFLAG = 1 THEN Y$=MID$(SLINE$,Y+1,F-(Y+1))
710 PARAMETER$ = Y$ : GOSUB 810
720 Y$=PARAMETER$
730 IF ZFLAG = 1 THEN Z$ = "00.000" ELSE Z$ = MID$(SLINE$,Z+1,F-(Z+1))
740 PARAMETER$ = Z$ : GOSUB 810
750 Z$=PARAMETER$
760 F$ = MID$(SLINE$,F+1,ENDLINE - (F+1))
770 PARAMETER$= F$ : GOSUB 810
780 F$ = PARAMETER$
790 GOTO 870
800 REM
810 REM ********** SUBROUTINE TO DELETE SPACES *************
820 REM
830 SPACE = INSTR ( PARAMETER$," " ) : LENGTH = LEN (PARAMETER$)
840 IF SPACE = 0 THEN RETURN
850 PARAMETER$ = LEFT$(PARAMETER$,SPACE-1) + RIGHT$(PARAMETER$,LENGTH - SPACE):G
OTO 830
860 REM
870 IF LEFT$(X$,1) <> "+" AND LEFT$(X$,1) <> "-" THEN X$="+" + X$
880 IF LEFT$(Y$,1) <> "+" AND LEFT$(Y$,1) <> "-" THEN Y$="+" + Y$
890 IF LEFT$(Z$,1) <> "+" AND LEFT$(Z$,1) <> "-" THEN Z$="+" + Z$
900 IF LEN(X$) > 7 OR LEN(Y$) > 7 OR LEN(Z$) > 7 OR LEN (F$) > 6 THEN GOTO 1730
910 XPNT=INSTR(X$,".") : YPNT=INSTR(Y$,".") : ZPNT=INSTR(Z$,".") : FPNT=INSTR(F$
,".")
920 IF XPNT>4 OR YPNT>4 OR ZPNT>4 OR FPNT>4 THEN GOTO 1730
930 REM
940 REM ********************************
950 REM * INTERPOLATE MOVE
960 REM ********************************
970 REM
980 XDIST=VAL(X$) : YDIST=VAL(Y$) : ZDIST=VAL(Z$) : FEED=VAL(F$)
990 TLDIST=SQR( (XDIST ^ 2) + (YDIST ^ 2) + (ZDIST ^ 2) )
1000 TIME=TLDIST/FEED
1010 XSPEED=ABS(XDIST/TIME) : YSPEED=ABS(YDIST/TIME) : ZSPEED=ABS(ZDIST/TIME)
1020 IF (XSPEED < 1.65 AND XSPEED > 0) OR (YSPEED < 1.65 AND YSPEED > 0) OR (ZSP
EED < 1.65 AND ZSPEED >0) THEN GOSUB 1860
```

```
1030 IF XSPEED > 112 OR YSPEED > 112 OR ZSPEED > 112 THEN GOSUB 2030
1040 DISTANCE= (-1) * XDIST : SPEED=XSPEED
1050 GOSUB 1240
1060 XCY$=CY$
1070 DISTANCE= (-1) * YDIST : SPEED=YSPEED
1080 GOSUB 1240
1090 YCY$=CY$
1100 DISTANCE=ZDIST : SPEED=ZSPEED
1110 GOSUB 1240
1120 ZCY$=CY$
1130 REM
1140 REM ********************************
1150 REM * SAVE MOVE TO CY FILE
1160 REM ********************************
1170 REM
1180 CYMOVE$(I)=CHR$(34)+XCY$ + " : " + YCY$ + " : " + ZCY$+CHR$(34)
1190 NEXT I
1200 FOR LINES = 1 TO 100
1210 PRINT #2,CYMOVE$(LINES)
1220 NEXT LINES
1230 GOTO 370
1240 REM ***************************************
1250 REM * ROUTINE TO CONVERT DATA TO CY512 COMMANDS
1260 REM ***************************************
1270 REM
1275 IF DISTANCE = 0 THEN CY$="I,N 0" : RETURN
1280 IF DISTANCE < 0 THEN DIRECTION$="-"
1290 IF DISTANCE >= 0 THEN DIRECTION$="+"
1300 STEPS = CINT(ABS(DISTANCE * 1600))
1310 REM *** CALCULATE RATE AND FACTOR FOR CY512 ***
1320 SS = SPEED * 26.667
1330 IF SS < 43.5 THEN SS = 43.5
1340 IF SS > 3000 THEN SS = 3000
1350 RATE = CINT(257.938 - (12500! / SS))
1360 IF RATE < 1 THEN RATE = 1
1370 IF RATE > 253 THEN RATE = 253
1380 FACTOR = CINT ((8 * RATE) + (100000! / SS) - 2055.5)
1390 IF FACTOR < 1 THEN RATE = RATE + 1:GOTO 1380
1400 REM *****************************************
1410 REM *  CHECK TO SEE IF R, AND F ARE BEST
1420 REM ******************************************
1430 FMIN = FACTOR - 1:F = FACTOR:FPLUS = FACTOR + 1
1440 FEXP=FMIN:GOSUB 1530
1450 ERRMIN = SSERR
1460 FEXP=FPLUS:GOSUB 1530
1470 ERRPLUS = SSERR
1480 FEXP = F:GOSUB 1530
1490 IF ERRMIN >= SSERR AND ERRPLUS >= SSERR THEN GOTO 1580
1500 IF ERRMIN < SSERR THEN FACTOR = FACTOR - 1:GOTO 1420
1510 IF ERRPLUS < SSERR THEN FACTOR = FACTOR + 1:GOTO 1420
1520 PRINT:PRINT "ERROR IN R AND F CHECK ROUTINE":END
1530 REM ***** CALCULATE SS FROM R AND F VALUES *****
1540 DENOM= (((256 - RATE) * 80) + (FEXP * 10) + 75) * .000001
1550 SSEXP= 1/DENOM
1560 SSERR=ABS(SS-SSEXP)
1570 RETURN
```

```
1580 REM ** CALCULATE SLOPE **
1585 IF SPEED < 12 THEN SLOPE = 255 : GOTO 1630
1590 SLOPE = 1
1600 YY = 2 * ( INT(( 255 - FACTOR ) / SLOPE ))
1610 IF SLOPE > 254 THEN GOTO 1630
1620 IF YY > STEPS THEN SLOPE = SLOPE + 1 : GOTO 1600
1630 RATE$=STR$(RATE):SLOPE$=STR$(SLOPE):FACTOR$=STR$(FACTOR):STEPS$=STR$(STEPS)
1640 CY$="R"+RATE$+",S"+SLOPE$+",F"+FACTOR$+",N"+STEPS$+","+DIRECTION$
1650 RETURN
1660 REM
1670 REM ******************************
1680 REM * LINE OUT OF ORDER ERROR
1690 REM ******************************
1700 REM
1705 PRINT CHR$(7)
1710 PRINT:PRINT "PARAMETERS OUT OF ORDER IN LINE# ";NLINE
1720 PRINT:END
1730 REM *********************************
1740 REM * NUMERICAL VALUE ERROR
1750 REM *********************************
1760 REM
1765 PRINT CHR$(7)
1770 PRINT:PRINT "NUMERICAL VALUE ERROR IN LINE# ";NLINE
1780 PRINT "TOO MANY DIGITS OR DECIMAL POINT MISPLACED"
1790 PRINT:END
1800 REM ******************************
1810 REM * PARAMETER MISSING ERROR
1820 REM ******************************
1830 REM
1835 PRINT CHR$(7)
1840 PRINT:PRINT "N,F, OR $ PARAMETER MISSING IN LINE# ";NLINE
1850 PRINT:END
1860 REM *********************************
1870 REM * AXIS SPEED < 1.65 ERROR
1880 REM *********************************
1890 REM
1895 AXIS$=" "
1900 IF XSPEED < 1.65 AND XSPEED > 0 THEN AXIS$="X-AXIS"
1910 IF YSPEED < 1.65 AND YSPEED > 0 THEN AXIS$=AXIS$+",Y-AXIS"
1920 IF ZSPEED < 1.65 AND ZSPEED > 0 THEN AXIS$=AXIS$+",Z-AXIS"
1930 PRINT CHR$(7)
1940 PRINT:PRINT "FEED RATE TOO SLOW IN LINE# ";NLINE
1950 PRINT "INTERPOLATION CAUSES ";AXIS$;" TO BE TOO SLOW"
1960 PRINT "( ";AXIS$;" SPEED WILL BE ROUNDED UP )"
1970 PRINT:PRINT "PUSH <RETURN> TO CONTINUE OR <ESCAPE> TO ABORT"
1980 Q$=INKEY$:IF LEN(Q$) = 0 THEN GOTO 1980
1990 IF Q$=CHR$(27) THEN PRINT:END
2000 IF Q$ <> CHR$(13) THEN PRINT CHR$(7):GOTO 1970
2010 PRINT:PRINT "----------------------------------------":RETURN
2020 REM
2030 REM **********************************
2040 REM * AXIS SPEED > 112 ERROR
2050 REM **********************************
2060 REM
2070 IF XSPEED > 112 AND ZSPEED > 112 THEN AXIS$= "X AND Z-AXIS": GOTO 2110
2080 IF XSPEED > 112 THEN AXIS$= "X-AXIS"
```

```
2090 IF ZSPEED > 112 THEN AXIS$= "Z-AXIS"
2100 PRINT CHR$(7)
2110 PRINT:PRINT "FEED RATE TOO FAST IN LINE# ";NLINE
2120 PRINT "INTERPOLATION CAUSES ";AXIS$;" TO BE TOO FAST"
2130 PRINT "( ";AXIS$;" SPEED WILL BE ROUNDED DOWN )"
2140 PRINT:PRINT "PUSH <RETURN> TO CONTINUE OR <ESCAPE> TO ABORT"
2150 Q$=INKEY$:IF LEN(Q$)=0 THEN GOTO 2150
2160 IF Q$=CHR$(27) THEN PRINT:END
2170 IF Q$ <> CHR$(13) THEN PRINT CHR$(7):GOTO 2140
2180 PRINT:PRINT "----------------------------------------":RETURN
2181 REM
2182 REM *********************************
2183 REM *  ROUTINE TO HANDLE 'NO FILE' ERRORS
2184 REM *********************************
2185 REM
2186 IF ERR = 53 OR ERR = 64 THEN PRINT:PRINT "ERROR: FILE NOT FOUND OR BAD FILE
 NAME!":PRINT:INPUT "PUSH <RETURN> TO CONTINUE",XXX$
:GOTO 2310
2187 ON ERROR GOTO 0
2189 REM
2190 REM
2200 REM ******************************
2210 REM * END OF OPERATION
2220 REM ******************************
2230 REM
2240 FOR LINES = 1 TO (I-1)
2250 PRINT #2,CYMOVE$(LINES)
2260 NEXT LINES
2270 PRINT #2,"$$$$$"
2280 CLOSE
2290 PRINT CHR$(7):REM:PRINT CHR$(7):REM:PRINT CHR$(7)
2300 PRINT:PRINT:PRINT RS274$;"==>";CY512$;" TRANSLATION COMPLETED"
2310 PRINT:CHAIN MENU$
2320 END
```

```
10 REM *****************************************************
20 REM *
30 REM *  CYEXEC.BAS      BY  JUSTIN D. REDD    - BYU CAM LAB -
40 REM *                                        DECEMBER, 1983
50 REM *
60 REM *  THIS PROGRAM READS IN A FILE WITH THE FILENAME EXTENTION
70 REM *  .CYC THAT HAS BEEN CREATED BY THE INTERP.BAS PROGRAM
80 REM *  FROM AN RS274 TEXT FILE.  IT THEN EXECUTES THE CY512
90 REM *  COMMANDS CONTAINED IN THE FILE AND TERMINATES.
100 REM*
110 REM******************************************************
120 REM
130 REM **********************************
140 REM * CHECK FOR CYDRIVER.HEX IN MEMORY
150 REM **********************************
160 REM
170 PRINT:INVERSE:PRINT "CHECKING FOR CYDRIVER.HEX";:NORMAL:PRINT
180 MESS$=""
190 FOR CHAR = 0 TO 6
200 LOCATION = &HC4F1 + CHAR
210 CHAR$=CHR$(PEEK(LOCATION))
220 MESS$=MESS$ + CHAR$:CHAR$= ""
230 NEXT CHAR
240 IF LEFT$(MESS$,5) <> "VALID" THEN GOTO 270
250 X$=MID$(MESS$,6,1)
260 IF X$="1" THEN GOTO 360
270 PRINT:INVERSE:PRINT "LOADING CYDRIVER.HEX AT C400H";:NORMAL:PRINT
280 PRGM$="CYEXEC.BAS":SLINE=330:HFILE$="CYDRIVER.HEX"
290 CALLER$="XXXX":CLINE=999
300 CHAIN "BLOAD.BAS",10,ALL
310 CLEAR,&HC400
320 DEF USR1=&HC409
330 DEF USR2=&HC416
340 DEF USR3=&HC423
350 REM
360 REM **********************************
370 REM * READ IN CY512 FILE
380 REM **********************************
390 REM
400 HOME : PRINT "CY512 FILE EXECUTER             - BYU CAM LAB -
410 PRINT:PRINT "----------------------------------------------------------------
---------------":PRINT:PRINT:PRINT
420 INPUT "EXECUTE WHAT CY512 COMMAND FILE ";CYFILE$
430 TEST$=RIGHT$ (CYFILE$,4)
440 IF LEFT$ (TEST$,1) = "." THEN GOTO 465
450 CYFILE$ = CYFILE$ + ".CYC"
460 ON ERROR GOTO 1070
465 IF MID$(CYFILE$,2,1) = ":" THEN LLL = 14 ELSE LLL = 12
470 IF LEN (CYFILE$) > LLL THEN PRINT:PRINT "FILENAME TOO LONG!":PRINT:GOTO 420
480 IF RIGHT$(CYFILE$,4) = ".CYC" THEN GOTO 530
490  PRINT:PRINT "THIS FILE DOES NOT HAVE THE FILENAME EXTENTION '.CYC'.  IT WIL
L RUN ONLY IF THE FILE IS AN INTERPRETED TEXT FILE O
F CY512 COMMANDS."
500 PRINT:PRINT "DO YOU STILL WANT TO TRY TO EXECUTE THIS FILE ? (Y/N)";
510 ANSWER$=INKEY$:IF LEN(ANSWER$) = 0 THEN GOTO 510
520 IF ANSWER$ <> "Y" THEN GOTO 1040
```

```
530 OPEN"I",#1,CYFILE$
540 ON ERROR GOTO 0
550 PRINT:INVERSE:PRINT "READING IN ";CYFILE$;:NORMAL:PRINT
560 NLINE=0
570 NLINE = NLINE + 1
580 INPUT #1,CLINE$
590 IF CLINE$ = "$$$$$" THEN LINES = NLINE - 1 : GOTO 610
600 GOTO 570
610 DIM CY$(NLINE,3)
620 DIM CLINE$(NLINE)
630 CLOSE
640 OPEN"I",#1,CYFILE$
650 FOR I = 1 TO LINES
660 INPUT #1,CLINE$(I)
670 NEXT I
680 CLOSE
690 REM
700 REM *********************************
710 REM * SEPARATE X,Y, AND Z AXIS
720 REM *********************************
730 REM
740 PRINT:INVERSE:PRINT "SEPARATING X,Y, AND Z AXIS COMMANDS - LINE#";:NORMAL:PR
INT
750 FOR I = 1 TO LINES
760 XX=(LINES-I) + 1
770 COLON1=INSTR(CLINE$(I),":")
780 COLON2=INSTR((COLON1+1),CLINE$(I),":")
790 CY$(I,1)=LEFT$(CLINE$(I),COLON1 - 2)
800 CY$(I,2)=MID$(CLINE$(I),(COLON1+2),((COLON2-1)-(COLON1+2)))
810 CY3LEN=LEN(CLINE$(I)) - (COLON2 + 1)
820 CY$(I,3)=RIGHT$(CLINE$(I),CY3LEN)
830 VTAB (11) :HTAB (44):INVERSE:PRINT XX;
840 CLINE$(I) = ""
850 NEXT I
860 VTAB (11) : HTAB (44) : INVERSE : PRINT " 0      " : PRINT
870 PRINT "CLEARING MEMORY"
880 REM
890 REM *********************************
900 REM *  EXECUTE MOVES
910 REM *********************************
920 REM
930 NORMAL
940 PRINT CHR$(7) : PRINT "************** READY ****************" :PRINT CHR$(7
950 FOR I = 1 TO LINES
960 IF FRE(0) < 100 THEN PRINT "CLEARING MEMORY - PLEASE WAIT":PRINT FRE("")
970 Q$=USR1(CY$(I,1))
980 Q$=USR2(CY$(I,2))
990 Q$=USR3(CY$(I,3))
1000 Q$=USR1("G"):Q$=USR2("G"):Q$=USR3("G")
1010 NEXT I
1020 PRINT:PRINT "EXECUTION COMPLETE"
1030 CLEAR,&HC400
1040 CHAIN "MENU.BAS",360
1050 END
1060 REM
1070 REM **********************************
```

```
1080 REM *  ROUTINE TO HANDLE 'NO FILE' ERRORS
1090 REM **********************************
1100 REM
1110 IF ERR = 53 OR ERR = 64 THEN PRINT: PRINT "ERROR: FILE NOT FOUND OR BAD FIL
E NAME!":PRINT:INPUT "PUSH <RETURN> TO CONTINUE",XXX
$:GOTO 1040
1120 ON ERROR GOTO 0
```

```
10 REM ***************************************************
20 REM *
30 REM *           MZERO.BAS      BY JUSTIN D. REDD
40 REM *                             - BYU CAM LAB -
50 REM *
60 REM *  THIS PROGRAM WILL SEND ALL THREE AXIS' (X,Y, AND Z)
70 REM *  OF THE MINI-MILLING MACHINE TOWARD THEIR HOME
80 REM *  POSITIONS.  IT THEN BEGINS CHECKING THE AXIS LIMIT
90 REM *  SWITCHES, STOPPING EACH AXIS WHEN IT IS IN IT'S
100 REM *  HOME POSITION.  THIS PROGRAM IS USUALLY RUN BEFORE
110 REM *  RUNNING A SEQUENCE OF MOVES ON THE MILL SINCE IT
120 REM *  PROVIDES A CONSISTENT AND ACCURATE STARTING LOCATION.
130 REM *
140 REM ****************************************************
150 REM *
160 COMMON MENU$
170 REM
180 PRINT:PRINT
190 PRINT "=====> ";:INVERSE:PRINT"ZEROING MILL";:NORMAL:PRINT" <====="
200 PRINT
210 STAT1=&HE0F0 : STAT2=&HE0F1 : STAT3=&HE0F2
220 CY1$="I,R 250,S 1,F 1,N 20000,-,G"
230 GOSUB 350:GOSUB 270:GOSUB 310
240 HOME
250 CHAIN MENU$
260 END
270 CALL CY1(CY1$)
280 X$=RIGHT$((HEX$(PEEK(STAT1))),1)
290 IF ASC(X$) > 55 THEN POKE STAT1,&H44:POKE STAT1,&H40 : RETURN
300 GOTO 280
310 CALL CY2(CY1$)
320 Y$=RIGHT$((HEX$(PEEK(STAT2))),1)
330 IF ASC(Y$) > 55 THEN POKE STAT2,&H44:POKE STAT2,&H40 : RETURN
340 GOTO 320
350 CALL CY3(CY1$)
360 Z$=RIGHT$((HEX$(PEEK(STAT3))),1)
370 IF ASC(Z$) > 55 THEN POKE STAT3,&H44:POKE STAT3,&H40 : RETURN
380 GOTO 360
```

```
10 REM *********************************************************
20 REM *
30 REM *        LZERO.BAS          BY JUSTIN D. REDD
40 REM *                              - BYU CAM LAB -
50 REM *
60 REM *  THIS PROGRAM SENDS BOTH AXIS' OF THE LATHE (X AND Z)
70 REM *  BACK TOWARDS THEIR HOME POSITIONS.  IT THEN BEGINS
80 REM *  CHECKING THE LIMIT SWITCHES ON EACH AXIS AND STOPS
90 REM *  THE MOTORS WHEN THE LATHE IS IN HOME POSITION.  THIS
100 REM*  PROGRAM IS USUALLY RUN BEFORE A CUTTING ROUTINE TO
110 REM*  MAKE SURE THE LATHE STARTS FROM THE SAME POSTION EACH
120 REM*  TIME.
130 REM*
140 REM**********************************************************
150 REM *
160 PRINT:PRINT
170 PRINT "=====> ";:INVERSE:PRINT"ZEROING LATHE";:NORMAL:PRINT" <====="
180 PRINT:PRINT
190 STAT1=&HE0F0 : STAT2=&HE0F2
200 CY1$="I,R 250,S 1,F 1,N 10000,+,G" : CY2$="I,R 250,S 1,F 1,N 20000,-,G"
210 Q$=USR1(CY1$)
220 X$=RIGHT$((HEX$(PEEK(STAT1))),1)
230 IF ASC(X$) > 55 THEN POKE STAT1,&H44:POKE STAT1,&H40:GOTO 250
240 GOTO 220
250 Q$=USR3(CY2$)
260 Z$=RIGHT$((HEX$(PEEK(STAT2))),1)
270 IF ASC(Z$) > 55 THEN POKE STAT2,&H44:POKE STAT2,&H40:GOTO 290
280 GOTO 260
290 CY1$="R 100,S 1,F 1,N 50,+,G":CY2$="R 100,S 1,F 1,N 50,-,G"
300 Q$=USR1(CY1$):Q$=USR3(CY2$)
310 HOME
320 CHAIN "MENU"
330 END
```

APPENDIX K

Turret Punch Control Program

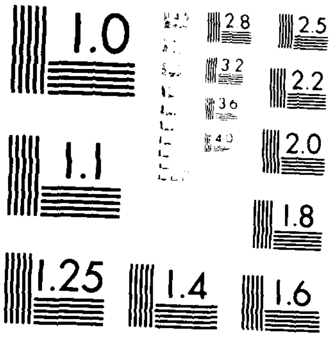
AD-A152 715   MANUFACTURING INFORMATION SYSTEM(U) BRIGHAM YOUNG UNIV   3/3
PROVO UT COMPUTER AIDED MFG LAB D K ALLEN ET AL.
26 DEC 84 AFOSR-TR-85-0275 AFOSR-82-0253

UNCLASSIFIED   F/G 13/8   NL

END

FILMED

DTIC



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

```
]LIST

5  REM  ******************************
6  REM  *
7  REM  *  MANUAL PUNCH
8  REM  *      BY
9  REM  *  JUSTIN D. REDD
10  REM *
11  REM *  THIS APPLESOFT PROGRAM WILL
12  REM *  RUN THE MINI TURRET PUNCH
13  REM *  THROUGH STEP BY STEP CONTROL.
14  REM *
15  REM *******************************
16  REM  *
35 CP = 1
40 D$ =  CHR$ (4): REM  CNTL-D
50  PRINT D$;"BRUN CY DRIVER.OBJ,A$4000"
60  CALL 16384
70  PRINT  CHR$ (1);"1R 252,S 1,F 1,N 0,-"
75 Q =  USR (1)
80  PRINT  CHR$ (1);"2R 252,S 1,F 1,N 0,-"
85 Q =  USR (2)
90  PRINT  CHR$ (1);"3R 250,S 1,F 1,N 0,+,A"
95 Q =  USR (3)
100  PRINT  CHR$ (1)"4R 250,S 1,F 1,N 0,-"
105 Q =  USR (4)
106  PRINT  CHR$ (1);"4N 1200,-,G"
107 Q =  USR (4)
110 PD = 1200: REM  ** PUNCH DIST.
120  REM  ** CP=CURRENT PUNCH, DR$=DIRECTION
130 P1 = 0: REM  ** POSITION OF PUNCH 1
140 P2 = 251: REM  ** POSITION OF PUNCH 2
150 P3 = 501: REM  ** POSITION OF PUNCH 3
160 P4 = 751: REM  ** POSITION OF PUNCH 4
200  REM  *** MAIN MENU ***
205  HOME : PRINT
210  PRINT "****************************************": PRINT "***
                                  ***": PRINT "***       MANUAL PUNCH MAIN MENU
        ***": PRINT "***                                  ***"
220  PRINT "****************************************"
230  VTAB (10): HTAB (5): PRINT "1) PUNCH HOLE"
240  VTAB (12): HTAB (5): PRINT "2) CHANGE PUNCH SIZES"
250  VTAB (14): HTAB (5): PRINT "3) MOVE X-AXIS"
260  VTAB (16): HTAB (5): PRINT "4) MOVE Y-AXIS"
270  VTAB (18): HTAB (5): PRINT "5) QUIT"
280  VTAB (21): HTAB (10): PRINT "WHICH? "
285  VTAB (24): PRINT "<^D>=DOWN <^U>=UP <^L>=LEFT <^R>=RIGHT
290  GET A$: PRINT A$: PRINT
295  IF A$ = "1" THEN  GOTO 1000
300  IF A$ = "2" THEN  GOTO 2000
310  IF A$ = "3" THEN  GOTO 3000
320  IF A$ = "4" THEN  GOTO 4000
331  IF A$ =  CHR$ (4) THEN  GOTO 5000
332  IF A$ =  CHR$ (21) THEN  GOTO 5500
333  IF A$ =  CHR$ (12) THEN  GOTO 6000
334  IF A$ =  CHR$ (18) THEN  GOTO 6500
```

```
335  IF A$ <  > "5" THEN  GOTO 200
340  PRINT  CHR$ (1);"3N 250"
345 Q =  USR (3)
350  PRINT  CHR$ (1);"3P 0"
355 Q =  USR (3)
356  PRINT  CHR$ (1);"3N 250"
357 Q =  USR (3)
360  PRINT  CHR$ (1);"4N 1200,+,G"
365 Q =  USR (4)
370  HOME : END
1000  REM  ** SUB TO PUNCH **
1010  HOME : VTAB (11): HTAB (16): FLASH : PRINT ">>> PUNCHING <<<": NORMAL

1020  PRINT  CHR$ (1);"4N ";PD;",+,G"
1030 Q =  USR (4)
1040  PRINT  CHR$ (1);"4-,G"
1050 Q =  USR (4)
1060  GOTO 200
2000  REM  ** SUB TO ROTATE TURRET **
2010  HOME
2020  PRINT : PRINT "          ROTATE TURRET"
2030  PRINT : PRINT "****************************************"
2032  IF CP = 0 THEN  GOTO 2040
2034 VT = 6 + (2 * CP)
2036  VTAB (VT): FLASH : PRINT "==>": NORMAL
2040  VTAB (8): HTAB (5): PRINT "1) SMALL PUNCH (? IN.)"
2050  VTAB (10): HTAB (5): PRINT "2) MEDIUM/SMALL PUNCH (? IN.)"
2060  VTAB (12): HTAB (5): PRINT "3) MEDIUM/LARGE PUNCH (? IN.)"
2070  VTAB (14): HTAB (5): PRINT "4) LARGE PUNCH (? IN.)"
2080  VTAB (16): HTAB (5): PRINT "5) RETURN TO MAIN MENU "
2090  VTAB (19): HTAB (10): PRINT "WHICH?"
2100  GET T$
2110  IF T$ = "1" THEN P = P1: GOTO 2200
2120  IF T$ = "2" THEN P = P2: GOTO 2200
2130  IF T$ = "3" THEN P = P3: GOTO 2200
2140  IF T$ = "4" THEN P = P4: GOTO 2200
2150  IF T$ = "5" THEN  GOTO 200
2200  PRINT  CHR$ (1);"3P ";P
2210 Q =  USR (3)
2220 CP =  VAL (T$)
2230  GOTO 2000
3000  REM  ** SUB TO MOVE X-AXIS **
3005  HOME
3010  PRINT : PRINT "               MOVE X-AXIS"
3020  PRINT : PRINT "****************************************": PRINT
3025  GOTO 3300
3030  VTAB (8): HTAB (5): PRINT "1) + DIRECTION"
3040  VTAB (10): HTAB (5): PRINT "2) - DIRECTION"
3050  VTAB (12): HTAB (5): PRINT "3) RETURN TO MAIN MENU"
3060  VTAB (15): HTAB (10): PRINT "WHICH? "
3070  GET X$
3080  IF X$ = "1" THEN  VTAB (8): FLASH : PRINT "==>": NORMAL :DR$ = "+": GOTO
     3200
3090  IF X$ = "2" THEN  VTAB (10): FLASH : PRINT "==>": NORMAL :DR$ = "-":
      GOTO 3200
3100  IF X$ = "3" THEN  GOTO 200
```

```
3110  GOTO 3000
3200  VTAB (20): INPUT "DISTANCE ? (IN.) ";ND$
3210  IF  ASC (ND$) > 58 THEN  GOTO 3200
3220 N =  VAL (ND$) * 1600
3230  RETURN
3300  GOSUB 3030
3310  PRINT  CHR$ (1);"1N ";N;",";DR$;",G"
3320 Q =  USR (1)
3330  PRINT  CHR$ (1);"1N 0"
3340 Q =  USR (1)
3350  GOTO 3000
4000  REM  ** SUB TO MOVE Y-AXIS **
4010  HOME
4020  PRINT : PRINT "               MOVE Y-AXIS"
4030  PRINT : PRINT "*************************************": PRINT
4040  GOSUB 3030
4050  PRINT  CHR$ (1);"2N ";N;",";DR$;",G"
4060 Q =  USR (2)
4070  PRINT  CHR$ (1);"2N 0"
4080 Q =  USR (2)
4090  GOTO 4000
5000  REM  *** MOVE PUNCH DOWN ***
5010  PRINT  CHR$ (1);"4+"
5020 Q =  USR (4)
5030  PRINT  CHR$ (1);"4+,N 100,G"
5040 Q =  USR (4)
5050  GOTO 200
5500  REM  *** MOVE PUNCH UP ***
5510  PRINT  CHR$ (1);"4-"
5520 Q =  USR (4)
5530  PRINT  CHR$ (1);"4-,N 100,G"
5540 Q =  USR (4)
5550  GOTO 200
6000  REM  *** TURRET LEFT 1 STEP ***
6010  PRINT  CHR$ (1);"3N 1"
6020 Q =  USR (3)
6030  PRINT  CHR$ (1);"3N 1,-,G"
6040 Q =  USR (3)
6050  GOTO 200
6500  REM  *** TURRET RIGHT 1 STEP ***
6510  PRINT  CHR$ (1);"3N 1"
6520 Q =  USR (3)
6530  PRINT  CHR$ (1);"3N 1,+,G"
6540 Q =  USR (3)
6550  GOTO 200
```

APPENDIX L

Programs for the Miniature Storage and Retrieval System

```
10 REM**********************************************************************
12 REM****                                                               ****
13 REM****       STACKER.BAS     BY  DAVE JESPERSON     - BYU CAM LAB ****
14 REM****   This program communicates with the apple computer through ****
15 REM****   the serial interface.  The apple program that accepts the ****
16 REM****   data from the IBM PC is called STACKER.BAS also, and is   ****
17 REM****   run from Microsoft Basic.                                  ****
20 REM****                                                             ****
30 REM****                   VARIABLE DEFINITIONS                      ****
40 REM****                                                             ****
50 REM****  CMD$        = introduction command chosen                  ****
60 REM****  MCMD$       = main menu option chosen                      ****
70 REM****  TCMD$       = transport menu option chosen                 ****
80 REM****  CLEARLINE$ = holds 39 blank spaces, used to clear a line  ****
90 REM****  X & Y       = holds screen coordinates                     ****
100 REM***  I,J         = loop variables                               ****
110 REM***  BINNO       = user entered bin number                      ****
120 REM***  TRAYNO      = user entered delivery tray number            ****
130 REM***  FLAG        = mark/unmark bin                              ****
140 REM***                FLAG = 1: mark bin                           ***
150 REM***                FLAG = 0: unmark bin                         ****
160 REM***  BIN(18)     = array of bin numbers                         ****
170 REM***  ROW(18)     = array of cursor row locations                ****
180 REM***  COL(18)     = array of cursor column locations             ****
190 REM***  STATUS(2)   = array to track status of delivery trays      ****
200 REM***  MISTAKE     = pointer into error array                     ****
210 REM***  ERRORMESG$ = array of error messages                      ****
220 REM***  BINNO$(19) = array of alphabetical bin numbers            ****
230 REM***  TRAYNO$     = character input variable for tray number     ****
232 REM***  JUNK$       = accept any charater from key board           ****
234 REM***  STOPIT      = used to stop program when error exists       ****
235 REM***  VSKIP$      = stores line coordinates for DRAW command     ****
236 REM***  HSKIP$      = same as VSKIP$                               ****
237 REM***  TAG         = used in RETURN BIN to hold tray number       ****
240 REM***                                                             ****
250 REM*********************************************************************
260 REM
270 REM*****************************************
280 REM****
290 REM****    DISPLAY SWITCH
300 REM****
310 REM*****************************************
320 REM
330 DEF SEG = 0: POKE &H410, (PEEK(&H410) AND &HCF) OR &H10
340 SCREEN 1,0,0,0 : SCREEN 0: WIDTH 40
350 REM
360 REM*****************************************
370 REM****
380 REM****     SYSTEM INITIALIZATION
400 REM****
410 REM*****************************************
420 REM
430 DIM BINNO$(19), BIN(19), ROW(19), COL(19), STATUS(2), ERRORMESG$(12)
440 CLEARLINE$ = SPACE$(39)
442 BINNO$(1)="11":BIN(1)=11:ROW(1)=12:COL(1)=4
444 BINNO$(2)="12":BIN(2)=12:ROW(2)=8:COL(2)=4
446 BINNO$(3)="13":BIN(3)=13:ROW(3)=4:COL(3)=4
448 BINNO$(4)="21":BIN(4)=21:ROW(4)=12:COL(4)=10
450 BINNO$(5)="22":BIN(5)=22:ROW(5)=8:COL(5)=10
```

```
460 BINNO$(10)="41":BIN(10)=41:ROW(10)=12:COL(10)=22
462 BINNO$(11)="42":BIN(11)=42:ROW(11)=8:COL(11)=22
464 BINNO$(12)="43":BIN(12)=43:ROW(12)=4:COL(12)=22
466 BINNO$(13)="51":BIN(13)=51:ROW(13)=12:COL(13)=28
468 BINNO$(14)="52":BIN(14)=52:ROW(14)=8:COL(14)=28
470 BINNO$(15)="53":BIN(15)=53:ROW(15)=4:COL(15)=28
472 BINNO$(16)="61":BIN(16)=61:ROW(16)=12:COL(16)=34
474 BINNO$(17)="62":BIN(17)=62:ROW(17)=8:COL(17)=34
476 BINNO$(18)="63":BIN(18)=63:ROW(18)=4:COL(18)=34
480 ERRORMESG$(1) =  "INVALID INPUT"
485 ERRORMESG$(2) =  "RANGE ERROR"
490 ERRORMESG$(3) =  "ALL BINS RETURNED"
495 ERRORMESG$(4) =  "BIN(S) STILL OUT"
500 ERRORMESG$(5) =  "DELIVERY TRAYS FULL"
505 ERRORMESG$(6) =  "TRAY 1 OCCUPIED"
510 ERRORMESG$(7) =  "TRAY 2 OCCUPIED"
515 ERRORMESG$(8) =  "BIN DELIVERED"
520 ERRORMESG$(9) =  "BIN RETURNED"
525 ERRORMESG$(10) =  "BIN DOES NOT EXIST"
530 ERRORMESG$(11) =  "NO SUCH TRAY"
535 ERRORMESG$(12) =  " "
550 STATUS(1) = 0: STATUS(2) = 0
552 CLS:COLOR 23: PRINT "INITIALIZING MULTIPLEXER - PLEASE WAIT" : COLOR 7
555 OPEN "COM1: 4800,N,7,2,CS1000,DS1000" AS #1
556 MUXMESG1$=CHR$(2)+"1":MUXMESG2$=CHR$(1)+"1"
557 PRINT #1,MUXMESG1$; :X=11:GOSUB 565 : PRINT #1,"2"; :X=8:GOSUB 565
558 PRINT #1,"5"; :X=11 :GOSUB 565 : PRINT #1,"1"; : PRINT #1,MUXMESG2$;
560 GOTO 570
565 FOR I = 1 TO X
566 INPUT #1,A$
567 NEXT I
568 RETURN
569 REM
570 REM*****************************************
580 REM****
590 REM****     INTRODUCTION SCREEN
600 REM****
610 REM*****************************************
620 REM
630 KEY OFF: SCREEN 0,1: COLOR 15,0,0: WIDTH 40: CLS
640 LOCATE 3,12:  PRINT "Computer - Aided"
650 LOCATE 5,8:   PRINT "Manufacturing Laboratory"
660 LOCATE 8,8: COLOR 9: PRINT "BRIGHAM YOUNG UNIVERSITY"
670 LOCATE 10,11: PRINT "Provo, Utah  84602"
680 COLOR 15
690 LOCATE 15,9,0: PRINT CHR$(213)+STRING$(20,205)+CHR$(184)
700 LOCATE 16,9,0: PRINT CHR$(179)+"      Mini-LAB      "+CHR$(179)
710 LOCATE 17,9,0: PRINT CHR$(179)+"  Retrieval System  "+CHR$(179)
720 LOCATE 13,9,0: PRINT CHR$(179)+"     Utilities      "+CHR$(179)
730 LOCATE 19,9,0: PRINT CHR$(179)+"    Version 1.0     "+CHR$(179)
740 LOCATE 20,9,0: PRINT CHR$(212)+STRING$(20,205)+CHR$(190)
750 COLOR 12
760 LOCATE 24,7,0: PRINT "Press space bar to continue"
770 POKE 106, 0
780 CMD$ = INKEY$
790 IF CMD$ = ""  THEN GOTO 780
800 IF CMD$ = CHR$(27) THEN GOTO 840
810 IF CMD$ = " " THEN GOTO 920
820 GOTO 770
```

```
830 IF (STATUS(1)<>0)OR(STATUS(2)<>0) THEN MISTAKE=4: GOSUB 2130: GOTO 1020
835 EXITPRGM$="2"+CHR$(10):EXITPRGM$=RIGHT$(EXITPRGM$,2)
840 CLS:COLOR 7:WIDTH 80:KEY ON:GOSUB 3530:PRINT #1,EXITPRGM$
842 CLOSE #1: END
850 REM****************************************
860 REM****
870 REM****   SUBROUTINE   MAIN MENU
880 REM****
890 REM****
900 REM****
910 REM****************************************
920 REM
930 CLS: SCREEN 1,0: COLOR 9,1
940 LOCATE 4,8,1: PRINT "MINI-CAM RETRIEVAL SYSTEM"
950 LOCATE 11,3:  PRINT "MAIN MENU OPTIONS:"
960 DEF SEG: POKE &H4E, 2   'change pen color to magenta
970 LOCATE 14,10: PRINT "1. Transport control"
980 LOCATE 16,10: PRINT "2. Inventory Manager"
990 LOCATE 18,10: PRINT "3. Exit Program"
995 LOCATE 24,12 : PRINT "<CNTRL-D> for auto-run demo";
1000 LINE (43,11)-(267,43),,B: LINE (41,9)-(269,45),,B
1010 DEF SEG: POKE &H4E, 3:  'change pen color to white
1020 LOCATE 21,1 : PRINT CLEARLINE$
1030 LOCATE 21,3: PRINT;"ENTER OPTION **> ";
1033 MCMD$=INKEY$ : IF LEN (MCMD$) = 0 THEN GOTO 1033
1035 PRINT MCMD$;
1040 IF (MCMD$ = "1") THEN GOSUB 1520
1050 IF (MCMD$ = "2") THEN GOSUB 3000
1060 IF (MCMD$ = "3") THEN GOTO 830
1065 IF (MCMD$ = CHR$(4)) THEN GOSUB 4000
1067 IF DEMO > 0 THEN GOSUB 1520
1070 GOTO 930
1080 REM
1090 REM****************************************
1100 REM****
1110 REM****   SUBROUTINE RETRIEVAL DRAW
1120 REM****
1130 REM****************************************
1140 REM
1150 X = 12: Y = 4
1160 FOR I = 1 TO 6
1170     FOR J = 1 TO 3
1180         LOCATE X,Y: PRINT (I*10)+J;
1190         X = X - 4
1200     NEXT J
1210     X = 12: Y = Y + 6
1220 NEXT I
1230 VSKIP$ = "BD23 D10 BD22 D10 BD22 D10 R34 U10 BU22 U10 BU22 U10 BU23"
1240 HSKIP$ = "BR7 R34 BR14 R34 BR14 R34 BR14 R34 BR14 R34 BR14 R34"
1250 DRAW "C1; BM 15,15 R288 D97 L288 U97"
1260 DRAW "BM 15,15 R48 ND97 R48 ND97 R48 ND97 R48 ND97 R48 ND97"
1270 DRAW "BM 15,48 R288 BM 15,80 R288 BM 15,38 XHSKIP$; BM 15,70 XHSKIP$;"
1280 DRAW "BM 15,102 XHSKIP$;"
1290 X = 22: PSET(X,15)
1300 FOR I = 1 TO 6
1310    DRAW "C1; XVSKIP$;"
1320    X = X + 48: DRAW "BM =X;,15"
1330 NEXT I
1340 DEF SEG: POKE &H4E, 2
```

```
1350 IF STATUS(1) = 0 GOTO 1420
1360 I = 1
1370 WHILE (STATUS(1) <> BIN (I)) AND (I <= 18)
1380      I = I + 1
1390 WEND
1400 LOCATE ROW(I), COL(I): PRINT STATUS(1)
1410 LOCATE ROW(I)+2, COL(I): PRINT "at 1";
1420 IF STATUS(2) = 0 GOTO 1490
1430 I = 1
1440 WHILE (STATUS(2) <> BIN(I)) AND (I <= 18)
1450      I = I + 1
1460 WEND
1470 LOCATE ROW(I), COL(I): PRINT STATUS(2);
1480 LOCATE ROW(I)+2, COL(I): PRINT "at 2";
1490 DEF SEG: POKE &H4E, 3
1500 RETURN
1510 REM
1520 REM****************************************
1530 REM****
1540 REM****      TRANSPORT MENU
1550 REM****
1560 REM****************************************
1570 REM
1580 CLS: WIDTH 40: SCREEN 1,0: COLOR 9
1590 LOCATE 1,12 : PRINT "TRANSPORT CONTROL
1600 GOSUB 1090  'print retrival draw
1610 GOSUB 1800 'clear menu subroutine
1620 LOCATE 17,3 : PRINT "TRANSPORT MENU:"
1630 DEF SEG: POKE &H4E, 2
1640 LOCATE 19,12: PRINT "1. Retrieve Bin
1650 LOCATE 20,12: PRINT "2. Return Bin
1660 LOCATE 21,12: PRINT "3. Exit To Main Menu"
1670 DEF SEG: POKE &H4E, 3
1680 LOCATE 23,1 : PRINT CLEARLINE$;
1690 LOCATE 23,3 : PRINT;"ENTER OPTION #%  ";
1691 IF DEMO > 0 THEN DEMONO=DEMONO+1:IF DEMONO > 36 THEN GOTO 4500
1692 IF DEMO > 0 THEN READ TCMD:TCMD$=RIGHT$(STR$(TCMD),1):GOTO 1695
1693 TCMD$=INKEY$ : IF LEN(TCMD$) = 0 THEN GOTO 1693
1695 PRINT TCMD$;
1700 IF (TCMD$ = "1") THEN GOSUB 2420
1710 IF (TCMD$ = "2") THEN GOSUB 2670
1720 IF (TCMD$ = "3") THEN RETURN
1730 GOTO 1610
1740 REM
1750 REM****************************************
1760 REM****
1770 REM****       SUBROUTINE CLEAR MENU
1780 REM****
1790 REM****************************************
1800 REM
1810 FOR I = 17 TO 24
1820      LOCATE I,1: PRINT CLEARLINE$;
1830 NEXT
1840 RETURN
1850 REM
1860 REM****************************************
1870 REM****
1880 REM****     SUBROUTINE MARK-BIN
1890 REM****
1900 REM****************************************
```

```
1910 REM
1920 I = 1:
1930 WHILE (BINNO <> BIN(I)) AND (I <= 18)
1940     I = I + 1
1950 WEND
1960 IF FLAG = 1 GOTO 2010
1970 DEF SEG: POKE &H4E, 3
1980 LOCATE ROW(I), COL(I):   PRINT BINNO;
1990 LOCATE ROW(I)+2, COL(I): PRINT'    ';
2000 GOTO 2060
2010 DEF SEG: POKE &H4E,2
2020 LOCATE ROW(I), COL(I): PRINT BINNO;
2030 LOCATE ROW(I)+2, COL(I)
2040 IF TRAYNO = 1 THEN PRINT 'at 1' ELSE PRINT 'at 2'
2050 DEF SEG: POKE &H4E, 3
2060 RETURN
2070 REM
2080 REM*****************************************
2090 REM****
2100 REM****   SUBROUTINE ERROR MESSAGE
2110 REM****
2120 REM*****************************************
2130 REM
2140 STOPIT = 1
2150 LOCATE 25,1: PRINT CLEARLINE$;
2160 PRINT CHR$(7);
2170 DEF SEG: POKE &H4E, 1
2180 LOCATE 25,3: PRINT '***> ';ERRORMESG$(MISTAKE);' <***';
2190 JUNK$ = INKEY$: IF JUNK$ = '' THEN 2190
2200 LOCATE 25,1: PRINT CLEARLINE$;
2210 DEF SEG: POKE &H4E, 3
2220 RETURN
2230 REM
2240 REM****************************************
2250 REM****
2260 REM****  SUBROUTINE RETRIEVE CHECK
2270 REM****
2280 REM****************************************
2290 REM
2300 STOPIT = 0
2310 IF (TRAYNO = 1) AND (STATUS(1) <> 0) THEN GOTO 2320 ELSE GOTO 2330
2320     MISTAKE = 6: GOSUB 2130: RETURN
2330 IF (TRAYNO = 2) AND (STATUS(2) <> 0) THEN GOTO 2340 ELSE GOTO 2350
2340     MISTAKE = 7: GOSUB 2130
2350 RETURN
2360 REM
2370 REM****************************************
2380 REM****
2390 REM****  SUBROUTINE RETRIEVE BIN
2400 REM*****
2410 REM****************************************
2420 REM
2430 GOSUB 1800 'clear menu
2440 LOCATE 17,3: PRINT 'RETRIEVE BIN:'
2450 IF (STATUS(1)<>0)AND(STATUS(2)<>0) THEN MISTAKE=5: GOSUB 2130: RETURN
```

```
2460 GOSUB 2850   'input bin number
2470 LOCATE 25,1: PRINT CLEARLINE$;
2480 IF BINNO = 0 THEN RETURN
2490 IF(BINNO=STATUS(1))OR(BINNO=STATUS(2))THEN MISTAKE=8:GOSUB 2130:GOTO 2460
2492 IF STATUS(1) <> 0 AND STATUS(2) = 0 THEN TRAYNO$ = "2" : GOTO 2517
2494 IF STATUS(1) = 0 AND STATUS(2) <> 0 THEN TRAYNO$ = "1" : GOTO 2517
2500 LOCATE 21, 1:  PRINT CLEARLINE$;
2510 LOCATE 21,3:   PRINT;"DELIVERY TRAY **> ";
2511 IF DEMO > 0 THEN READ TRAYNO:TRAYNO$=RIGHT$(STR$(TRAYNO),1) : GOTO 2515
2513 TRAYNO$=INKEY$ : IF LEN(TRAYNO$) = 0 THEN GOTO 2513
2515 PRINT TRAYNO$;:GOTO 2520
2517 LOCATE 21,3:   PRINT;"DELIVERY TRAY **> ";TRAYNO$;
2520 IF(TRAYNO$<>"1")AND(TRAYNO$<>"2") THEN MISTAKE=11: GOSUB 2130: GOTO 2500
2530 IF TRAYNO$ = "1" THEN TRAYNO = 1 ELSE TRAYNO = 2
2540 GOSUB 2290 'check routine
2550 IF STOPIT = 1 GOTO 2500
2560 FLAG = 1
2580 STATUS(TRAYNO) = BINNO
2585 GOSUB 3530
2590 OP$="1"+CHR$(10):B$=STR$(BINNO)+CHR$(10):T$=STR$(TRAYNO)+CHR$(10)
2591 OP$=RIGHT$(OP$,2):PRINT #1,OP$;:RLINE=1:GOTO 3460
2592 B$=RIGHT$(B$,3):PRINT #1,B$;:RLINE = 2:GOTO 3460
2593 T$=RIGHT$(T$,2):PRINT #1,T$;
2595 GOSUB 1910 'mark routine
2600 RETURN
2610 REM
2620 REM******************************************
2630 REM****
2640 REM****  SUBROUTINE RETURN BIN
2650 REM****
2660 REM******************************************
2670 REM
2680 GOSUB 1800  'clear menu
2690 LOCATE 17,3: PRINT "RETURN BIN:"
2700 IF(STATUS(1)=0)AND(STATUS(2)=0) THEN MISTAKE=3:GOSUB 2130: RETURN
2702 IF STATUS(1) <> 0 AND STATUS(2) = 0 THEN BIN$=RIGHT$(STR$(STATUS(1)),2) : G
OSUB 2905 : GOTO 2720
2704 IF STATUS(1) = 0 AND STATUS(2) <> 0 THEN BIN$=RIGHT$(STR$(STATUS(2)),2) : G
OSUB 2905 : GOTO 2720
2710 GOSUB 2850 ' input bin number
2720 LOCATE 25,1: PRINT CLEARLINE$;
2730 IF BINNO = 0 THEN RETURN
2740 IF (STATUS(1)<>BINNO) AND (STATUS(2)<>BINNO) THEN GOTO 2750 ELSE GOTO 2760
2750     MISTAKE = 9: GOSUB 2130: GOTO 2710
2760 FLAG = 0
2780 IF STATUS(1)=BINNO THEN STATUS(1)=0: TAG=1 ELSE STATUS(2)=0: TAG=2
2781 GOSUB 3530
2782 OP$="0"+CHR$(10):B$=STR$(BINNO)+CHR$(10):T$=STR$(TAG)+CHR$(10)
2783 OP$=RIGHT$(OP$,2):PRINT #1,OP$;:RLINE=3:GOTO 3460
2784 B$=RIGHT$(B$,3):PRINT #1,B$;:RLINE=4:GOTO 3460
2785 T$=RIGHT$(T$,2):PRINT #1,T$;
2788 GOSUB 1910  'SUBROUTINE MARK BIN
2790 RETURN
2800 REM*******************************************
2810 REM****
2820 REM****   SUBROUTINE INPUT BIN NUMBER
2830 REM****
2840 REM*******************************************
2850 REM
```

```
2860 DEF SEG: POKE &H4E,1
2870 LOCATE 25,12: PRINT CHR$(26)+ ' Q)UIT to exit ' +CHR$(27);
2880 DEF SEG: POKE &H4E,3
2890 LOCATE 19,1:  PRINT CLEARLINE$
2895 IF DEMO > 0 THEN READ BIN:BIN$=RIGHT$(STR$(BIN),2) : GOTO 2905
2900 LOCATE 19,3:  INPUT;'BIN NUMBER  **> ',BIN$ : GOTO 2910
2905 LOCATE 19,3:  PRINT;'BIN NUMBER  **> ';BIN$
2910 IF (BIN$='Q') OR (BIN$='QUIT') THEN BINNO = 0: RETURN
2920 I = 1
2930 WHILE (BIN$ <> BINNO$(I)) AND (I < 19)
2940     I = I + 1
2950 WEND
2960 IF I = 19 THEN MISTAKE = 10: GOSUB 2130: GOTO 2860
2970 BINNO = BIN (I)
2980 RETURN
2990 REM
3000 REM****************************************
3010 REM****
3020 REM****   SUBROUTINE INVENTORY MENU
3030 REM****
3040 REM****************************************
3050 REM
3060 CLS: WIDTH 40: SCREEN 1,0: COLOR 9
3070 LOCATE 1,12 : PRINT 'INVENTORY MANAGER'
3080 GOSUB 1090
3090 LOCATE 17,3 : PRINT 'INVENTORY MENU'
3100 DEF SEG: POKE &H4E, 2
3110 LOCATE 19,12: PRINT '1. System Editor'
3120 LOCATE 20,12: PRINT '2. List Empty Bins'
3130 LOCATE 21,12: PRINT '3. List All Bins'
3140 LOCATE 22,12: PRINT '4. Return To Main Menu'
3150 DEF SEG: POKE &H4E, 3
3160 LOCATE 24,1 : PRINT CLEARLINE$;
3170 LOCATE 24,3 : INPUT;'ENTER OPTION **> ',ICMD$
3180 IF (ICMD$ = '1') THEN
3190 IF (ICMD$ = '2') THEN
3200 IF (ICMD$ = '3') THEN
3210 IF (ICMD$ = '4') THEN RETURN
3220 GOTO 3160
3400 REM******************************************
3410 REM****
3420 REM****  READY TO TRANSMIT HANDSHAKE
3430 REM****  WITH APPLE
3440 REM****
3450 REM******************************************
3460 INPUT #1,CHECK$
3461 X=INSTR(CHECK$,'OK'):Y=INSTR(CHECK$,'WHAT?')
3462 IF X=0 AND Y=0 THEN GOTO 3460
3463 IF Y<>0 THEN ON RLINE GOTO 2591,2592,2783,2784
3464 FOR I = 1 TO 25:NEXT I
3465 ON RLINE GOTO 2592,2593,2784,2785
3480 REM******************************************
3490 REM****
3500 REM****  CHECK CLEAR TO SEND LINE ON APPLE
3510 REM****
3520 REM******************************************
```

```
3530 INPUT #1,CHECK$
3540 X=INSTR(CHECK$,'READY')
3550 IF X=0 THEN GOTO 3530
3560 RETURN
4000 REM ****************************************
4010 REM ***
4020 REM ***   AUTO-RUN DEMO SETUP
4030 REM ***
4040 REM ****************************************
4050 REM
4060 CLS : PRINT 'THE DEMO ROUTINE WILL AUTOMATICALLY '
4070 PRINT        'CYCLE THROUGH ALL THE DRAWERS' :PRINT:PRINT:PRINT
4080 PRINT 'DO YOU STILL WANT TO USE THE DEMO ?(Y/N)';
4090 DEMO$=INKEY$ : IF LEN(DEMO$) = 0 THEN GOTO 4090
4100 IF DEMO$ <> 'Y' THEN RETURN
4110 PRINT:PRINT:PRINT:INPUT 'CYCLE THROUGH HOW MANY TIMES ?',DEMO$
4120 IF ASC(DEMO$) < 48 OR ASC(DEMO$) > 57 THEN GOTO 4110
4130 DEMO=VAL(DEMO$)
4135 DEMONO = 0
4140 DATA 1,43,1,1,22,2,43,2,1,61,1,1,11,2,61,2,1,52,1,1,33,2,52,2
4150 DATA 1,41,1,1,23,2,41,2,1,63,1,1,13,2,63,2,1,53,1,1,31,2,53,2
4160 DATA 1,42,1,1,21,2,42,2,1,62,1,1,12,2,62,2,1,51,1,1,32,2,51,2
4165 DATA 1,11,1,2,11
4170 RETURN
4500 REM *****************************************
4510 REM ***
4520 REM ***  CHECK FOR ANOTHER CYCLE IN DEMO
4530 REM ***
4540 REM *****************************************
4550 REM
4560 DEMO = DEMO - 1
4570 IF DEMO = 0 THEN PRINT '3';:RETURN
4580 DEMONO = 0
4590 RESTORE
4600 GOTO 1692
```

```
      [illegible](271,47),8,1,,,1: CIRCLE(271,47),24,1,,,1: CIRCLE(271,47),40,1,,,1
      [illegible] BM 271,3 D40 BD3 D2 BD3 D40 BM 227,47 R40 BR3 R2 BR3 R40"
      PARAM$(1,1) = "AI0": GOSUB 3230
3540 LOCATE 7,1 : LINE INPUT; PARAM$(3,2) 'LARGEST DIAM (#1)
3550 LOCATE 14,7: LINE INPUT; PARAM$(3,1) 'LENGTH OF LARGEST DIAM (#1)
3560 LOCATE 16,9: LINE INPUT; PARAM$(4,1) 'LENGTH DIAM #1 AND #2
3570 LOCATE 18,11: LINE INPUT; PARAM$(5,1) 'LENGTH DIAM #1,2 AND 3
3580 LOCATE 6,19: LINE INPUT; PARAM$(5,2) 'WIDTH SMALLEST DIAM (#3)
3590 LOCATE 7,24: LINE INPUT; PARAM$(4,2) 'WIDTH DIAM #2
3600 LENGTHDIAM=VAL(PARAM$(5,1))-VAL(PARAM$(4,1)):PARAM$(5,1)=STR$(LENGTHDIAM) '
FIND LENGTH OF DIAM #3
3610 LENGTHDIAM=VAL(PARAM$(4,1))-VAL(PARAM$(3,1)):PARAM$(4,1)=STR$(LENGTHDIAM) '
FIND LENGTH OF DIAM #2
3620 RETURN
3630 REM SUBROUTINE INITIALIZE ARRAY
3640 FOR I = 1 TO 12
3650 FOR J = 1 TO 2: PARAM$(I,J) = "0"
3660 NEXT J: NEXT I
3670 RETURN
3680 '
3690 'CREATE PROCESS PLAN CONTROL FILE
3700 '
3710 OPEN "O",#TEMPF%,"PROCTEMP.TEX"
3720 CLS:INPUT "ENTER PART NUMBER (OR C TO CANCEL) ===>",PRTNUMB$
3730 IF PRTNUMB$="C" THEN CLOSE #TEMPF%:RETURN
3740 PRINT #TEMPF%,PRTNUMB$ 'SAVE PART NUMBER IN FILE THAT WILL BECOME NAME OF N
EW CON FILE
3750 CLOSE #TEMPF%
3760 OPEN "O",#TEMPF%,"PROCONT.BAT"
3770 PRINT #TEMPF%,"TREE" 'RUN DLCASS LAB MAINLINE TO EXECUTE PROCESS PLAN CREAT
E TREE
3780 PRINT #TEMPF%,"PROCCON"
3790 CLOSE #TEMPF%
3800 SYSTEM 'EXITS BASIC AND WILL NOW EXECUTE BATCH FILE PROCONT - PROCESS CONTR
OL CONTINUED
3810 '
3812 '**************************
3814 '
3820 'EXECUTE ROUTINE
3830 '
3834 '**************************
3836 '
3840 EXITEXCT%=0
3842 '
3850 GOSUB 3990 'CLEAR SCREEN
3852 '
3860 GOSUB 4020 'CHECK FOR OPERATOR INPUT
3862 '
3870 IF MFIX%=1 THEN MFIX%=0:GOTO 3940 'FIXING PROCESS WHERE MUX MISSED CNTL-A
3880 IF EXITEXCT%=1 THEN EXITEXCT%=0:RETURN 'EXIT EXECUTE ROUTINE
3890 IF NEPROC%=1 THEN GOSUB 5030:NEPROC%=0:GOTO 3850 'PUT NEXT STEP IN NEW PROC
ESS PLAN IN MACHINE QUE, THEN CHECK AGAIN FOR A NEW PROCESS PLAN TO EXECUTE
3900 IF JOBSRUNG%=0 GOTO 3850 'NO JOBS RUNNING TO CHECK ON
3902 '
3910 GOSUB 4400 'CHECK FOR MACHINE FINISHED
3912 '
3920 IF MACHRDY%=0 THEN GOTO 3850 'NO MACHINES READY FOR NEXT PROCESS
3930 IF NONEFIN%=1 THEN GOTO 3960 'NO PROCESSES READY FOR NEXT PROCESS
3932 '
3940 GOSUB 5030 'PUT NEXT STEP IN PROCESS PLAN IN MACHINE QUE
3942 '
3950 IF MACHRDY%=0 THEN GOTO 3850 'JOB FINISHED FOR THE MACHINE THAT REQUESTED A
[illegible]

[illegible] MACHINE NEXT MOVE
```

```
[illegible] HOLD%=1 TO 2000:NEXT:IF LOC(MUXF%)=0 THEN PRINT"HAVING PROBLEMS RECIEVI
[illegible]LE":GOTO 2920
2930 ANSWER$=INPUT$(LOC(MUXF%),#MUXF%):X=INSTR(ANSWER$,"READY"):IF X=0 THEN PRIN
T"DIDN'T RECIEVE READY FORM LATHE":GOTO 2910
2940 PRINT #MUXF%,"DESIGN";CHR$(10); 'SELECT DESIGN OPTION
2950 INPUT #MUXF%,ANSWER$:X=INSTR(ANSWER$,"UK"):IF X=0 THEN PRINT"DIDN'T TAKE DE
SIGN CHOICE":GOTO 2940
2960 FOR HOLD%=1 TO 2000:NEXT:IF LOC(MUXF%)=0 THEN GOTO 2960
2970 ANSWER$=INPUT$ (LOC(MUXF%),#MUXF%):X=INSTR(ANSWER$,"PLOADED"):IF X=0 THEN P
RINT"HAVING PROBLEMS RECIEVING FROM APPLE":PRINT #MUXF%,"BAD";CHR$(10);:GOTO 296
0
2980 PRINT #MUXF%,"OK";CHR$(10);
2990 INPUT #MUXF%,ANSWER$:X=INSTR(ANSWER$,"GOOD"):IF X=0 THEN PRINT "HAVING PROB
LEMS SENDING TO IBM":PRINT"APPLE SENT ==>";ANSWER$:GOTO 2960
3000 'PRINT #1,PARAM$(1,1)
3010 'GOSUB 1630
3020 PRINT #MUXF%,PARAM$(1,2);CHR$(10); 'PART NAME
3030 GOSUB 3200
3040 PRINT"TRANSMITTING DATA";
3050 'PRINT #MUXF%,PRTFAMLY$;CHR$(10);:GOSUB 1980 'PART FAMILY
3060 PRINT #MUXF%,PARAM$(2,1);CHR$(10);:PRINT".";:GOSUB 3200 'PART NUMBER
3070 PRINT #MUXF%,NUMBDIAM$;CHR$(10);:PRINT".";:GOSUB 3200 'NUMBER OF DIAMETERS
3080 PRINT #MUXF%,PARAM$(12,1);CHR$(10);:GOSUB 3200 'FEED RATE
3090 PRINT #MUXF%,PARAM$(12,2);CHR$(10);:PRINT".";:GOSUB 3200 'CUT DEPTH
3100 PRINT #MUXF%,STOCKWDTH$;CHR$(10);:GOSUB 3200 'STOCK DIAMETER
3110 PRINT #MUXF%,STOCKLEN$;CHR$(10);:PRINT".";:GOSUB 3200 'STOCK LENGTH
3120 FOR I = 3 TO VAL(NUMBDIAM$)+2
3130   FOR J = 1 TO 2
3140     PRINT #MUXF%, PARAM$(I,J);CHR$(10); 'PART DIMENSIONS
3150     GOSUB 3200
3160   NEXT J
3170 NEXT I
3180 GOSUB 3630
3190 RETURN
3200 REM TIMING LOOP
3210 FOR KK = 1 TO 100: NEXT KK
3220 RETURN
3230 REM SUBROUTINE TO DRAW TITLE BLOCK
3240 LINE(106,148)-(317,197),3,B
3250 LINE(104,146)-(319,199),3,B
3260 LINE(106,171)-(317,171)
3270 LOCATE 20,23,0: PRINT "PART NAME";
3280 LOCATE 23,16,0: PRINT "BASIC SHAPE: ";PARAM$(1,1)
3290 LOCATE 24,16,0: PRINT "PART NUMBER:";
3300 DEF SEG: POKE &H4E,2
3310 LOCATE 20,1,0 : PRINT "enter data";
3320 LOCATE 22,1,0 : PRINT "at cursor";
3330 LOCATE 24,2,0 : PRINT "position";
3340 DEF SEG: POKE &H4E, 3
3350 LOCATE 21,16,1: LINE INPUT; PARAM$(1,2)
3360 LOCATE 24,29,1: LINE INPUT; PARAM$(2,1)
3370 RETURN
3380 REM SUBROUTINE A20
3390 CLS: SCREEN 1,0: COLOR 0,1: KEY OFF
3400 LOCATE 2,2,0: PRINT CHR$(24): LOCATE 11,2: PRINT CHR$(25)
3410 LOCATE 5,19 : PRINT CHR$(25): LOCATE 8,19: PRINT CHR$(24)
3420 LOCATE 4,24 : PRINT CHR$(24): LOCATE 9,24: PRINT CHR$(25)
3430 LOCATE 13,6 : PRINT CHR$(27): LOCATE 13,9: PRINT CHR$(26)
3440 LOCATE 15,6 : PRINT CHR$(27): LOCATE 15,13: PRINT CHR$(26)
3450 LOCATE 17,6 : PRINT CHR$(27): LOCATE 17,17: PRINT CHR$(26)
3460 DRAW "C1: BM 39,7 D80 R32 U80 L32 BM 71,23 R32 D48 L32 BM 103,39 R32 D16 L3
2"
3470 DRAW "C2: BM 7,7 R29 L25 D32 BD16 D32 L4 R29 L24 U32 BU16 U32"
3480 [illegible] BM 39,[illegible] D44 U3 R40 BR16 R40 L40 BL16 L40 U16 R24 BR16 R24"
3490 [illegible] D12 BM 103,75 D44 BM 135,59 D76
3500 [illegible] D16 BD16 D16 R4 L24 R81 U16 BU16 U16 BM 139,39 R20 B
```

```
      [illegible] 1,2,0
     [illegible] = INKEY$: IF K$ [illegible] "" THEN GOTO 2270
     [illegible] = INKEY$: IF K$ = "" THEN GOTO 2290
2300 IF MID$(K$,1,1) = "1" THEN PRTFAMLY$="A00":NUMBDIAM$="1":GOSUB 2380
2310 IF MID$(K$,1,1) = "2" THEN PRTFAMLY$="A10":NUMBDIAM$="2":GOSUB 2530
2320 IF MID$(K$,1,1) = "3" THEN PRTFAMLY$="A20":NUMBDIAM$="3":GOSUB 3380
2330 IF MID$(K$,1,1) = "4" THEN GOSUB 2750
2340 IF MID$(K$,1,1) = CHR$(27) THEN GOTO 2360
2350 GOTO 2160
2360 SCREEN 0:WIDTH 80: COLOR 7,0
2370 RETURN
2380 REM Subroutine "A00"
2390 CLS: SCREEN 1,0: COLOR 0,1
2400 LINE (31,55)-(159,111),1,B
2410 LOCATE 5,5,0: PRINT CHR$(27)
2420 LOCATE 5,20 : PRINT CHR$(26)
2430 LOCATE 8,23 : PRINT CHR$(24)
2440 LOCATE 14,23: PRINT CHR$(25)
2450 DRAW "C3; BM 31,31 D21 U17 R56 BR16 R56 U4 D21"
2460 DRAW "BM 162,55 R20 L3 D20 BD16 D20 R4 L20 R17 U20 BU16 U20"
2470 CIRCLE(259,83),28,1,,,1
2480 DRAW "C3; BM 259,51 D28 BD2 D4 BD2 D28 BM 227,83 R28 BR3 R2 BR3 R28"
2490 PARAM$(1,1)  = "A00": GOSUB 3230
2500 LOCATE 4,12,0: LINE INPUT; PARAM$(3,1)    'OVERALL LENGTH
2510 LOCATE 11,22 : LINE INPUT; PARAM$(3,2)    'OVERALL DIAMETER
2520 RETURN
2530 REM SUBROUTINE  A10
2540 CLS: SCREEN 1,0: COLOR 0,1: KEY OFF
2550 PSET(63,47): DRAW "C1; R32 D88 L32 U88 BM 95,63 R32 D56 L32"
2560 CIRCLE(243,91),28,1,,,1: CIRCLE(243,91),44,1,,,1
2570 PSET(195,91) : DRAW "R44 BR3 R2 BR3 R44"
2580 PSET(243,43) : DRAW "D44 BD3 D2 BD3 D44"
2590 LOCATE 3,9,0 : PRINT CHR$(27): LOCATE 5,9,0 : PRINT CHR$(27)
2600 LOCATE 3,16,0: PRINT CHR$(26): LOCATE 5,12  : PRINT CHR$(26)
2610 LOCATE 9,19  : PRINT CHR$(24): LOCATE 15,19 : PRINT CHR$(25)
2620 LOCATE 7,6,0 : PRINT CHR$(24): LOCATE 17,6,0: PRINT CHR$(25)
2630 DRAW "BM 39,47 R20 BM 39,135 R20 BM 43,47 D40 BD8 D40"
2640 DRAW "BM 63,15 D27 BM 95,32 D12 BM 127,15 D43"
2650 DRAW "BM 63,19 R28 BR8 R28 BM 63,35 R12 BR8 R12"
2660 DRAW "BM 131,63 R20 BM 131,119 R20 BM 147,63 D24 BD8 D24"
2670 DRAW "BM 148,63 D24 BD8 D24 BM 44,47 D40 BD8 D40"
2680 PARAM$(1,1) = "A10": GOSUB 3230
2690 LOCATE 2,11,1: LINE INPUT; PARAM$(4,1)   'LENGTH DIAM #1 AND #2
2700 LOCATE 4,11,1: LINE INPUT; PARAM$(3,1)   'LENGTH OF LARGER DIAM (#1)
2710 LOCATE 12,4,1: LINE INPUT; PARAM$(3,2)   'WIDTH OF LARGER DIAM (#1)
2720 LOCATE 12,18,1: LINE INPUT; PARAM$(4,2)  'WIDTH OF SMALLER DIAM (#2)
2730 LENGTHDIAM=VAL(PARAM$(4,1))-VAL(PARAM$(3,1)):PARAM$(4,1)=STR$(LENGTHDIAM) '
FIND LENGTH OF DIAM #2
2740 RETURN
2750 REM APPLE DOWN-LOAD ROUTINE
2760 CLS: WIDTH 40: SCREEN 0,1: COLOR 15
2770 LOCATE 1,15: PRINT "IBM > APPLE"
2780 LOCATE 3,13: PRINT "DOWN-LOAD ROUTINE"
2790 LOCATE 7,2 : PRINT "PART NAME: ";PARAM$(1,2)
2800 LOCATE 9,2 : PRINT "PART NUMBER: ";PARAM$(2,1)
2810 LOCATE 11,2: PRINT "BASIC SHAPE: ";PARAM$(1,1)
2820 PRINT:INPUT "  ENTER STOCK LENGTH: ",STOCKLEN$
2830 PRINT:INPUT "  ENTER STOCK WIDTH: ",STOCKWDTH$
2840 PRINT:INPUT "  ENTER CUTTING SPEED: ",PARAM$(12,1)
2850 PRINT:INPUT "  ENTER CUTTING DEPTH: ",PARAM$(12,2)
2860 PRINT:PRINT "Press space bar when ready to send data"
2870 POKE 106,0: CMDD$ = INKEY$: IF CMDD$ <> " " GOTO 2870
2880 'SEND DATA TO APPLE
[illegible] INPUT[illegible]:GOSUB 4870 'TURN MUX PORT ON FOR LATHE
[illegible]PRINT"GETTING APPLE READY TO RECEIVE DATA"
[illegible] PRINT #[illegible],"READY";CHR$(10);
```

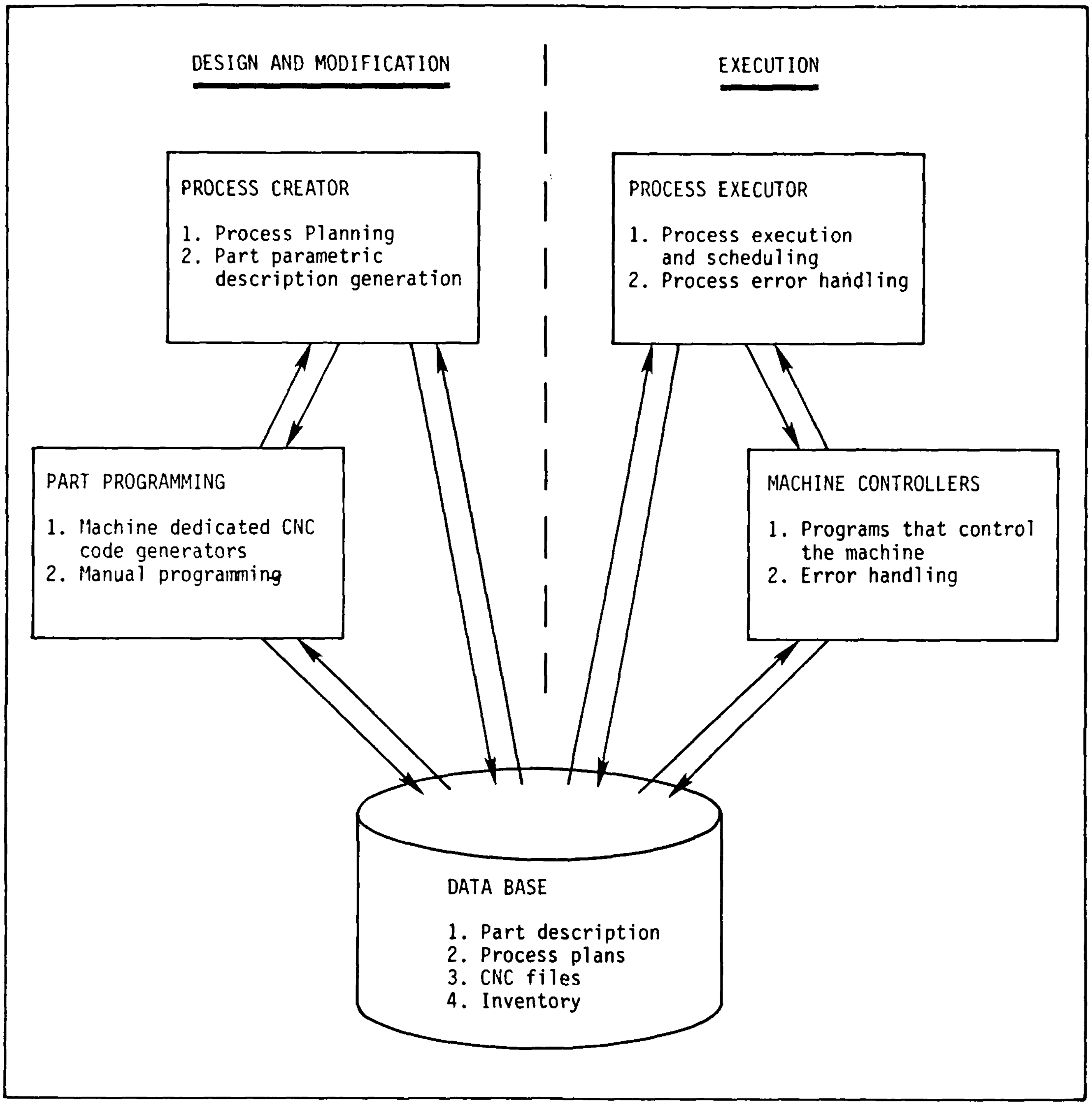
```
1720 PRINT:PRINT 'RECOPYING DCLASS ECREATED CONTROL FILE INTO FILE ';CONFILE$
1730 OPEN 'O',TEMPF2%,CONFILE$
1740 IF EOF(TEMPF%) GOTO 1790
1750 INPUT #TEMPF%,INLINE$
1760 PRINT #TEMPF2%,INLINE$
1770 PRINT'.';
1780 GOTO 1740
1790 CLOSE #TEMPF%:CLOSE #TEMPF2%
1800 PRINT:PRINT'NEW PROCESS CONTROL FILE ';CONFILE$;' IS READY':FOR HOLD%=1 TO
1500:NEXT
1810 RETURN
1820 'READ IN PART DIMENSIONES
1830 FOR DIAMN%=3 TO VAL(INPARAM$(4))+2
1840 FOR PRTPARM%=1 TO 2
1850 INPUT #TEMPF%,INLINE$
1860 INPUT #TEMPF%,EXTRACR$
1870 IF LEFT$(INLINE$,1)=' ' THEN INLINE$=MID$(INLINE$,2):GOTO 1500 'STRIP LEADI
NG SPACES
1880 GOSUB 5400 'STRIPS NODE NUMBER INSERTED BY THE DCLASS MAINLINE
1890 GOSUB 5400 'GET NEXT DIMENSION
1900 PARAM$(DIAMN%,PRTPARM%)=PARAM$ 'GET DIAMETER WIDTH OR LENGTH
1910 NEXT:NEXT
1920 RETURN
1930 '
1940 PRINT:PRINT'PROCESS CONTROL FILE ';CONFILE$' ALREADY EXISTS':PRINT 'YOU'LL
HAVE TO DELETE IT TO RUN PROGRAM':PRINT 'USE BASIC KILL '<FILE NAME>' COMMAND OR
 GO TO DOS AND DELETE IT':PRINT'THEN START THE PROGRAM AGAIN':END
1950 '
1952 '**********************************
1954 '
1960 'CREATE MODULE
1970 '
1972 '**********************************
1974 '
1980 CLS
1990 PRINT SPC(15);'OPTIONS FOR CREATING CNC ANC PROCESS CONTROL FILES'
2000 PRINT '*********************************************************************
***********'
2010 PRINT:PRINT'1. GENERATE LATHE CNC FILE USING GRAPHICS'
2020 PRINT:PRINT'2. GENERATE A PROCESS PLAN CONTROL PLAN FOR A CERTAIN PART NUMB
ER'
2030 PRINT:PRINT'3. RETURN TO MAIN MENU'
2040 PRINT:PRINT:PRINT'CHOOSE 1-3'
2050 ANSWER$=INKEY$:IF ANSWER$='' GOTO 2050
2060 IF ANSWER$='3' THEN RETURN 'LEAVE CREATE
2070 IF ANSWER$='1' THEN GOSUB 2100:GOTO 1970 'CNC CREATE
2080 IF ANSWER$='2' THEN GOSUB 3690:GOTO 1970 'CREATE CON FILE
2090 BEEP:GOTO 2050
2100 '
2110 'CNC CREATE SUBROUTINE W/GRAPHICS ADOPTED FROM A PROGRAM CALLED GRAPH WRITT
EN BY JUSTIN REDD
2120 '
2130 KEY OFF: SCREEN 0,1: COLOR 15,0,0: WIDTH 40: CLS
2140 GOSUB 3630
2150 GOTO 2160
2160 CLS
2170 SCREEN 0,1
2180 COLOR 7
2190 LOCATE 2,6,0: PRINT 'Graphics Utilities'
2200 LOCATE 5,6,0: PRINT '1 - A00'
2210 LOCATE 6,6,0: PRINT '2 - A10'
2220 LOCATE 7,6,0: PRINT '3 - A20'
2230 LOCATE 9,6,0: PRINT '4 - APPLE DOWNLOADER'
2240 LOCATE 10,6,0: PRINT 'ESC - EXIT GRAPHIC UTILITIES'
2250 COLOR 12
2260 LOCATE 20,6,0: PRINT 'Enter program number'
```

```
1150 ANSWER$=INKEY$:IF ANSWER$="" GOTO 1150
1160 IF ANSWER$="N" GOTO 1170 ELSE IF ANSWER$ <> "Y" GOTO 1290
1170 [illegible] PRINT#MUXF%,CHR$(1);"4"; 'TURN ON PORT 4 SO WILL INITIALIZE FASTER
1180 FOR PORT%=1 TO 4
1190 MUXMESG1$=CHR$(2) + RIGHT$(STR$(PORT%),1)
1200 PRINT #MUXF%,MUXMESG1$;
1210 PRINT"INITIALIZING PORT";PORT%
1220 FOR X% = 1 TO 11:INPUT #MUXF%,A$:NEXT 'LOAD IN MENU FROM MUX
1230 PRINT #MUXF%,"2"; 'CHOOSE CHANGE BAUD RATE OPTION
1240 FOR X% = 1 TO 8:INPUT #MUXF%,A$:NEXT
1250 PRINT #MUXF%,"5"; 'SELECTS BAUD RATE OF 4800 FOR PORT
1260 FOR X% = 1 TO 11:INPUT #MUXF%,A$:NEXT
1270 PRINT #MUXF%,"1"; 'QUITS CONFIGURATION MENU
1280 NEXT:INPUT #MUXF%,A$ 'GET LAST MENU RESPONSE
1290 READY$="READY" + CHR$(10)
1300 BAD$="BAD" + CHR$(10)
1310 OK$="OK" + CHR$(10)
1320 RETURN
1330 '
1332 '*********************************
1334 '
1340 'PROCESS TEMPORARY FILES
1350 '
1352 '*********************************
1354 '
1360 OPEN "O",#TEMPF%,"PROCONT.BAT" :CLOSE #TEMPF% 'NULIFY CONTENTS OF CONTINUAT
ION BATCH FILE
1370 '
1380 ON ERROR GOTO 1940
1390 OPEN "I",#TEMPF%,"PROCTEMP.TEX"
1400 IF EOF(TEMPF%) GOTO 1410 ELSE INPUT #TEMPF%,PRTNUMB$:CONFILE$=PRTNUMB$+".CO
N":GOTO 1420
1410 ON ERROR GOTO 0:CLOSE #TEMPF%:RETURN 'NO DCLASS FILES TO POST PROCESS
1420 CLOSE #TEMPF%
1430 ON ERROR GOTO 0
1440 OPEN "O",#TEMPF%,"PROCTEMP.TEX":CLOSE #TEMPF% 'NULIFY FILE CONTENTS
1450 CLS:PRINT"POST PROCESSING DCLASS FILE"
1460 OPEN "I",#TEMPF%,"FDC.PRT"
1470 PROCER1%=1
1480 INPUT #TEMPF%,INLINE$ 'GET NEXT PROCESS
1490 INPUT #TEMPF%,EXTRACR1$ 'BLEED OFF EXTRA CARRIAGE RETURNS INSERTED BY DCLAS
S
1500 IF LEFT$(INLINE$,1)=" " THEN INLINE$=MID$(INLINE$,2):GOTO 1500 'STRIP LEADI
NG SPACES
1510 GOSUB 5400 'STRIPS NODE NUMBER INSERTED BY THE DCLASS MAINLINE
1520 GOSUB 5400 'GET FIRST PARAMETER
1530 PRINT".";
1540 IF PROCER1%=1 THEN PROCER1%=0:IF VAL(PARAM$)=0 GOTO 1710 ELSE GOTO 1480 'TR
EE TRAVERSAL FLAG IS OFF.  NO CNC DATA WAS GENERATED
1550 PARAMID%=VAL(PARAM$) 'GET PARAMTER ID NUMBER
1560 IF PARAMID%=90 THEN GOSUB 1820:GOTO 1480 'READ IN PART DIMENSIONES
1570 IF PARAMID%=99 GOTO 1600 'FINISHED LOADING CNC DATA PARAMETERS
1580 GOSUB 5400:INPARAM$(PARAMID%)=PARAM$ 'SAVE PARAMTER IN PROPER LOCATION
1590 GOTO 1480 'PROCESS NEXT PARAMETER
1600 'SEND PARAMTERS TO APPLE
1610 PARAM$(1,2)=INPARAM$(1) 'PART NAME
1620 PARAM$(2,1)=INPARAM$(2) 'PART NUMBER
1630 PRTFAMLY$=INPARAM$(3) 'PART FAMILY
1640 NUMBDIAM$=INPARAM$(4) 'NUMBER OF DIFFERENT DIAMETERS
1650 PARAM$(12,1)=INPARAM$(5) 'FEED RATE
1660 PARAM$(12,2)=INPARAM$(6) 'CUT DEPTH
1670 [illegible]DPTH$=INPARAM$(7) 'STOCK DIAMETER
1680 [illegible]LENT$=INPARAM$(8) 'STOCK LENGTH
1690 [illegible] 2610 'DOWNLOADER ROUTINE

[illegible] PART CONTROL WITH NEW NAME
```

```
590 PRINT:PRINT"MAXIMUM NUMBER OF PROCESS PLANS TO BE EXECUTED AT SAME TIME IS";
MAXJOBS%
600 MUXF%=MAXJOBS% + 1 'COMMUNICATION FILE NUMBER
610 TEMPF%=MUXF%+1 'TEMPORARY FILE AND MISCELANEAOUS FILE NUMBER
620 TEMPF2%=TEMPF%+1 'SECOND TEMPORARY FILE NUMBER
630 JOBSRUNG%=0 'NUMBER OF JOBS RUNNING COUNTER
640 DIM RSTATUS%(MAXJOBS%) 'RUNNING STATUS OF EACH JOB
650 MAXSEQ%=3 'MAX NUMBER OF PROCESS STEPS IN DIRECT SEQUENCE FOR A PARTICULAR M
ACHINE
660 PRINT:PRINT"MAXIMUM NUMBER OF PROCESSES FOR ONE MACHINE IN SEQUENCE WITH THE
 HOLD FLAG":PRINT"OFF IN THE SAME PROCESS PLAN IS";MAXSEQ%-1
670 MAXQUES%=MAXJOBS% * MAXSEQ% 'MAX NUMBER OF QUES FOR EACH MACHINE
680 NUMBMACH%=8 'NUMBER OF MACHINES
690 PRINT:PRINT"CODE NUMBER FOR EACH MACHINE:"
700 TAB%=5
710     PRINT SPC(TAB%);"1 IS STACKER"
720     PRINT SPC(TAB%);"2 IS MINI-ROBOT"
730     PRINT SPC(TAB%);"3 IS BYU ROBOT"
740     PRINT SPC(TAB%);"4 IS TOYO LATHE"
750     PRINT SPC(TAB%);"5 IS EMCO LATHE"
760     PRINT SPC(TAB%);"6 IS POLAR MILL"
770     PRINT SPC(TAB%);"7 IS WETOFF MILL"
780     PRINT SPC(TAB%);"8 IS PUNCH"
790 DIM JOBSRUNG%(NUMBMACH%) 'STATUS OF EACH MACHINE
800 MAXPARAM%=7 'GREATEST NUMBER OF PARAMETERS
810 DIM MACHINEQUE$(NUMBMACH%,MAXQUES%,MAXPARAM%) 'CREATES A QUE FOR EACH MACHIN
E. WILL HOLD PARAMETERS NECESSARY TO RUN MACHINES
820     HLD%=2 'POSITON IN ARRAY OF PROCESS HOLD FLAG
830 DIM TEMP$(MAXPARAM%) 'TEMPRARY HOLDING ARRAY FOR MACHINE QUE PARAMETERS
840 DIM MQPARAMS%(NUMBMACH%) 'PARAMETERS NEED FOR EACH MACHINE IN THE QUE NOT IN
CLUDING THE 1ST RO 2ND PARAMETERS
850 MQPARAMS%(1)=3 'NUMBER OF PARAMETERS USED FOR STACKER
860 MQPARAMS%(2)=5 'NUMBER OF PARAMETERS USED FOR MINI ROBOT
870 MQPARAMS%(3)=3 'NUMBER OF PARAMETERS USED FOR BYU ROBOT
880 MQPARAMS%(4)=3 'NUMBER OF PARAMETERS USED FOR TOYO LATHE
890 MQPARAMS%(5)=3 'NUMBER OF PARAMETERS USED FOR EMCO LATHE
900 MQPARAMS%(6)=3 'NUMBER OF PARAMETERS USED FOR POLAR MILL
910 MQPARAMS%(7)=3 'NUMBER OF PARAMETERS USED FOR WESTOFF MILL
920 MQPARAMS%(8)=3 'NUMBER OF PARAMETERS USED FOR PUNCH
930 '0 IS USED TO SHOW END OF PROCESS CON FILE
940 DIM MQNEXT%(NUMBMACH%) 'HOLDS NUMBER OF NEXT POSTION IN QUE TO BE FILLED
950 DIM MQPOINTER%(NUMBMACH%) 'HOLDS NUMBER OF NEXT POSITION INQUE TO BE EXECUTE
D
960 FOR COUNTER%=1 TO NUMBMACH%:MQNEXT%(COUNTER%)=1:MQPOINTER%(COUNTER%)=1:NEXT
'INITIALIZE QUE POINTERS TO 1ST QUE
970 DIM HOLDING%(NUMBMACH%,MAXJOBS%,2) 'MACHINE HOLDING POINTERS
980     HJOB%=1 'POSITION IN ARRAY OF JOB FLAG
990     HQUE%=2 'OF QUE POINTER
1000 DIM HELD%(NUMBMACH%) 'HOLDS JOB NUMBER WHEN A MACHINE IS BEING HELD IDLE BY
 ANOTHER MACHINE THAT IS WAITING FOR IT TO BE READY
1010 DIM BSTATUS%(63) 'STATUS FLAG OF EACH BIN IN STACKER
1020 DIM TSTATUS%(2) 'STATUS FLAG OF 2 TRAYS
1030 DIM JSTATUS%(NUMBMACH%,2) 'JOB STATUS OF EACH MACHINE. 2 JOBS FOR STACKER
1040 QUECHECK%=1 'WILL START WITH MACHINE 1 WHEN CHECKING MACHINE QUES
1050 DIM PORT$(NUMBMACH%) 'HOLDS PORT NUMBER FOR EACH MACHINE
1060 PRINT:PRINT"MULTIPORT CONTROLLER PORT ALLOCATION:"
1070     PORT$(1)="1":PRINT"PORT FOR STACKER IS 1" 'PORT FOR MACHINE 1 - STACKER
1080     PORT$(2)="2":PRINT"PORT FOR MINI MOVER ROBOT IS 2"
1090     PORT$(4)="3":PRINT"PORT FOR TOYO LATHE IS 3"
1100 COLOR 4,0 :PRINT:PRINT "CAUTION - If above values are exceeded program may
crash"
1110 '
1120 'INITIALIZE MUX
1130 '
1140 OPEN "COM1:9600,N,7,2,CS4000,DS4000" AS #MUXF%:PRINT:PRINT"DOES MULTIPLEXO
R NEED TO BE INITIALIZED ? (Y)":COLOR 7,0
```

```
[illegible] ***************
* *************************************
110 '*         PART PROCESSOR BY GREGORY J. PETO        *
120 '*                                                  *
130 '*         THIS PROGRAM CONTROLS THE CREATION,      *
140 '*    MODIFICATION AND EXECUTION OF PART PROCESSES *
150 '*                                                  *
152 '****************************************************
154 '
160 ' This program is the main process controlling program.  It runs in
170 ' 3 modes, create, modify and execute.  The modify portion has not been
180 ' implemented yet.  The create mode has several options.  You can create a
190 ' part process by using the graphics routines written in basic or you can
200 ' select the option to leave basic and create a part process using the
210 ' DCLASS mainline TREE.  Upon reentry to basic the file created by DCLASS
220 ' is postprocessed and a .con file is created which is then executable.
222 '
223 ' The execute mode executes process control files.  The basic syntax is:
224 ' <machine #> <process hold code> <machine paramter list> <cr>
225 ' The program sets up a que for each machine.  Requests from each process
226 ' being executed are placed in the que for that machine.  As the machine
227 ' becomes available the next item in it's que is sent to the machine.
228 '*************************************************************************
250 '
260 'MAIN BODY OF PROGRAM
270 '
280 GOSUB 480 'INITIALIZE CONSTANTS
290 GOSUB 1330 'PROCESS TEMPORARY FILES
300 GOSUB 360 'GET MODE OF OPERATION
304 ' GO INTO MODE SELECTED
310 ON MODE% GOSUB 1970,440,3810 'CREATE,MODIFY,EXECUTE ROUTINES
320 GOTO 300 'GET MODE SELECTION AGAIN
330 '
340 '*****************************************************************
350 '
360 'GET MODE OF OPERATION
370 '
380 CLS:PRINT SPC(19);"MODES OF OPERATION FOR PART PROCESS PLANS":PRINT"********
***********************************************************************"
390 PRINT:PRINT"1. CREATE A PROCESS":PRINT:PRINT"2. MODIFY A PROCESS":PRINT:PRIN
T"3. EXECUTE PROCESS":ANSWER$=""
400 LOCATE 20:PRINT"CHOOSE 1-3":ANSWER$=INKEY$:IF ANSWER$="" THEN GOTO 400
410 MODE%=VAL(ANSWER$):IF MODE% <= 0 OR MODE% >3 THEN BEEP:GOTO 400
420 RETURN
430 '
440 'MODIFY ROUTINE NOT IMPLEMENTED YET
450 RETURN
460 '
462 '*********************************
464 '
470 'INITITALIZE AND DISPLAY CONSTANTS
480 '
484 '*********************************
486 '
490 WIDTH 80:SCREEN 0:CLS
500 OPTION BASE 1
510 DEBUG%=0:PRINT"DEBUG MODE ==>";DEBUG%
520 '
530 'VARIABLES USED BY CREATE ROUTINE
540
550 DIM PARAMS$(12,2)
560 [illegible] 'NEW PROCESS FLAG
570 [illegible]RDY% 'MACHINE READY FOR NEST STEP FLAG
580 [illegible]JOBS%=10 'MAXIMUM NUMBER OF JOBS RUNNING AT ONE TIME
```


DESIGN AND MODIFICATION
EXECUTION
PROCESS CREATOR
1. Process Planning
2. Part parametric description generation
PROCESS EXECUTOR
1. Process execution and scheduling
2. Process error handling
PART PROGRAMMING
1. Machine dedicated CNC code generators
2. Manual programming
MACHINE CONTROLLERS
1. Programs that control the machine
2. Error handling
DATA BASE
1. Part description
2. Process plans
3. CNC files
4. Inventory

APPENDIX M

CAD/CAM Demonstration Software Listings

```
2190 REM * HOOK BACK ONE INCH
2200 REM ****************************
2210 REM
2220 CY3$="P 1600"
2230 FOR I = 1 TO 2
2240 Q$=USR3(CY3$)
2250 NEXT I
2260 RETURN
2270 REM
2280 REM ****************************
2290 REM * HOOK ALL THE WAY BACK
2300 REM ****************************
2310 REM
2320 CY3$="P 16000"
2330 FOR I = 1 TO 2
2340 Q$=USR3(CY3$)
2350 NEXT I
2360 RETURN
2370 REM
```

```
1630 REM * GOTO BIN COODINATES
1640 REM ****************************
1650 REM
1660 CY1$="P" + STR$(BIN(XBIN,1))
1670 IF OPERATION = 1 THEN CY2$="P" + STR$( BIN(XBIN,2) + 385 )
1680 IF OPERATION = 0 THEN CY2$="P" + STR$( BIN(XBIN,2) )
1690 FOR I = 1 TO 2
1700 Q$=USR1(CY1$):Q$=USR2(CY2$)
1710 NEXT I
1720 RETURN
1730 REM
1740 REM ****************************
1750 REM * GOTO TRAY COORDINATES
1760 REM ****************************
1770 REM
1780 CY1$="P" + STR$(TRAY(XTRAY,1))
1790 IF OPERATION = 1 THEN CY2$="P" + STR$(TRAY(XTRAY,2))
1800 IF OPERATION = 0 THEN CY2$="P" + STR$( TRAY(XTRAY,2) + 385 )
1810 FOR I = 1 TO 2
1820 Q$=USR1(CY1$):Q$=USR2(CY2$)
1830 NEXT I
1840 RETURN
1850 REM
1860 REM ****************************
1870 REM * HOOK FORWARD
1880 REM ****************************
1890 REM
1900 CY3$="P 0"
1910 FOR I = 1 TO 2
1920 Q$=USR3(CY3$)
1930 NEXT I
1940 RETURN
1950 REM
1960 REM ****************************
1970 REM * ENGAGE HOOK
1980 REM ****************************
1990 REM
2000 IF FLAG$ = "BIN" THEN CY2$="P" + STR$( BIN(XBIN,2) )
2010 IF FLAG$ = "TRAY" THEN CY2$="P" + STR$( TRAY(XTRAY,2) )
2020 FOR I = 1 TO 2
2030 Q$=USR2(CY2$)
2040 NEXT I
2050 RETURN
2060 REM
2070 REM ****************************
2080 REM * DISENGAGE HOOK
2090 REM ****************************
2100 REM
2110 IF FLAG$="BIN" THEN CY2$="P" + STR$( BIN(XBIN,2) + 385 )
2120 IF FLAG$="TRAY" THEN CY2$="P" + STR$( TRAY(XTRAY,2) + 385 )
2130 FOR I = 1 TO 2
2140 Q$=USR2(CY2$)
2150 NEXT I
2160 RETURN
2170 REM
2180 REM ****************************
```

```
1050 REM
1060 REM ****************************
1070 REM * GOTO OPERATION# ROUTINE
1080 REM ****************************
1090 REM
1100 IF XTRAY < > 1 AND XTRAY < > 2 THEN PRINT "BAD TRAY# PASSED":GOTO 760
1110 IF XBIN > 63 OR XBIN < 11 THEN PRINT "BAD BIN# PASSED":GOTO 760
1120 N$=RIGHT$(STR$(XBIN),1)
1130 IF N$ <> "1" AND N$ <>"2" AND N$ <> "3" THEN PRINT "BAD BIN# PASSED":GOTO
60
1140 ON OPERATION + 1 GOTO 1150,1310,1470
1150 REM ****************************
1160 REM * RETURN BIN
1170 REM ****************************
1180 REM
1190 GOSUB 1730
1200 GOSUB 1860
1210 FLAG$="TRAY"
1220 GOSUB 1960
1230 GOSUB 2270
1240 GOSUB 1620
1250 GOSUB 1860
1260 FLAG$="BIN"
1270 GOSUB 2070
1280 GOSUB 2170
1290 GOTO 760
1300 REM
1310 REM ****************************
1320 REM * RETRIEVE BIN
1330 REM ****************************
1340 REM
1350 GOSUB 1620
1360 GOSUB 1860
1370 FLAG$="BIN"
1380 GOSUB 1960
1390 GOSUB 2270
1400 GOSUB 1730
1410 GOSUB 1860
1420 FLAG$="TRAY"
1430 GOSUB 2070
1440 GOSUB 2170
1450 GOTO 760
1460 REM
1470 REM ****************************
1480 REM * TERMINATE PROGRAM
1490 REM ****************************
1500 REM
1510 CY1$="P 0":CY2$="P 16795":CY3$="P 0"
1520 FOR I= 1 TO 2
1530 Q$=USR1(CY1$)
1540 Q$=USR2(CY2$)
1550 NEXT I
1590 HOME:PRINT "STACKER PROGRAM TERMINATED"
1600 PRINT:PRINT:END
1610 REM
1620 REM ****************************
```

```
560 TRAY(2,1)=2025:TRAY(2,2)=16350
570 REM
580 CY$="I,R 253,S 1,F 1,A,P 1,P 0"
585 MOTOR1$="I,R 251,S 1,F 1,A,P 1,P 0"
586 MOTOR1$=MOTOR1$+""
590 CY$=CY$+""
600 CY1$="XXX"+"":CY2$="XXX"+"":CY3$="XXX"+""
610 FOR I = 1 TO 2
620 Q$=USR1(MOTOR1$)
630 Q$=USR2(CY$)
640 Q$=USR3(CY$)
650 NEXT I
660 REM
670 REM ***************************
680 REM*MOVE CARRIER TO TOP AND REINITIALIZE
690 REM ***************************
700 REM
715 MOTOR2$="N 16795,-,G,A" 'MOVE CARRIER TO TOP"
716 Q$=USR2(MOTOR2$)
720 HOOK$="N 1600,-,G,A"
724 Q$=USR3(HOOK$) 'MOVE HOOK FORWARD ONE INCH AND SET AS HOME POSITION
730 GOSUB 2200 'MOVE HOOK BACK ONE INCH
745 Q$=USR8(IBM$)
746 W$="WHAT?"
747 Q$=USR7(W$)
750 REM
760 REM ***************************
770 REM * INPUT PARAMETERS FROM IBM
780 REM ***************************
790 REM
800 Q$="XXX" + "":OPERATION$="XXX"+"":XBIN$="XXX"+"":XTRAY$="XXX"+""
810 OK$="OK"+CHR$(13):WHAT$="WHAT?"+CHR$(13):READY$="READY"+CHR$(13)
815 Q$=USR7(READY$)
820 PRINT "OPERATION# = ";
840 Q$=USR8(OPERATION$):PRINT OPERATION$
850 IF OPERATION$ <> "0" AND OPERATION$ <> "1" AND OPERATION$ <> "2" THEN PRINT
 "INVALID OPERATION#":Q$=USR7(WHAT$):PRINT:GOTO 820
860 OPERATION = VAL(OPERATION$)
870 IF OPERATION = 2 THEN GOTO 1470
880 Q$=USR7(OK$)
890 PRINT "BIN# = ";
900 Q$=USR8(XBIN$):PRINT XBIN$
910 DATA 11,12,13,21,22,23,31,32,33,41,42,43,51,52,53,61,62,63
920 FOR I = 1 TO 18
930 READ X
940 IF VAL(XBIN$)=X THEN RESTORE: GOTO 1000
970 NEXT I
980 RESTORE:Q$=USR7(WHAT$):PRINT "BAD BIN#":PRINT:GOTO 890
1000 XBIN=VAL(XBIN$)
1005 Q$=USR7(OK$)
1010 PRINT "TRAY# = ";
1020 Q$=USR8(XTRAY$):PRINT XTRAY$
1025 IF XTRAY$ <> "1" AND XTRAY$ <> "2" THEN PRINT "BAD TRAY#":PRINT:Q$=USR7(WHA
T$):GOTO 1010
1030 XTRAY=VAL(XTRAY$)
1040 PRINT:PRINT "------------------------------":PRINT
```

```
]10 REM  ******************************************
20 REM  *  STORAGE AND RETRIEVAL SYSTEM CONTROLLER
30 REM  *         -BYU MINI-CAM LAB-
40 REM  *   ORIGINAL APPLESOFT VERSION BY DAVE JESPERSON
50 REM  *    MICROSOFT PROGRAM BY JUSTIN REDD
60 REM  *    OCTOBER, 1983
70 REM  *
80 REM  *   WHEN RUN, THIS PROGRAM WILL WAIT FOR 3
90 REM  *   PARAMETERS TO BE PASSED TO IT THROUGH
100 REM *   THE RS232 LINK.  THESE THREE PARAMETERS
110 REM *   ARE DEFINED AS THE OPERATION#,BIN#,AND
120 REM *   TRAY#.  OPERATION# 0 = RETURN BIN
130 REM *           OPERATION# 1 = RETRIEVE BIN
140 REM *           OPERATION# 2 = QUIT PROGRAM
150 REM *
160 REM *   TO RUN THIS PROGRAM CYDRIVER.HEX AND COMM.HEX
170 REM *   MUST BE LOADED INTO MEMORY.
180 REM *
190 REM *******************************************
200 REM
210 HOME:PRINT "           APPLE STACKER PROGRAM":PRINT:PRINT"----------------
----------------------------------"
220 PRINT:PRINT
230 REM ***************************
240 REM * LOAD CYDRIVER AND COMM
250 REM ***************************
260 REM
270 CALLER$="STACKER.BAS":CLINE=300:PRGM$="XXXX":SLINE=999:HFILE$="XXXX"
280 COMMON CALLER$,CLINE,PRGM$,SLINE,HFILE$
290 CHAIN "LOADASM.BAS"
300 REM
310 REM ***************************
320 REM * INITIALIZE
330 REM ***************************
340 REM
350 DIM BIN(63,2)
360 DIM TRAY(2,2)
370 BIN(11,1)=4085:BIN(11,2)=16375
380 BIN(12,1)=4138:BIN(12,2)=10750
390 BIN(13,1)=4138:BIN(13,2)=4925
400 BIN(21,1)=6140:BIN(21,2)=16375
410 BIN(22,1)=6140:BIN(22,2)=10675
420 BIN(23,1)=6212:BIN(23,2)=4775
430 BIN(31,1)=8200:BIN(31,2)=16375
440 BIN(32,1)=8269:BIN(32,2)=10775
450 BIN(33,1)=8262:BIN(33,2)=4875
460 BIN(41,1)=10250:BIN(41,2)=16375
470 BIN(42,1)=10300:BIN(42,2)=10750
480 BIN(43,1)=10312:BIN(43,2)=4925
490 BIN(51,1)=12287:BIN(51,2)=16375
500 BIN(52,1)=12312:BIN(52,2)=10800
510 BIN(53,1)=12344:BIN(53,2)=4850
520 BIN(61,1)=14320:BIN(61,2)=16375
530 BIN(62,1)=14337:BIN(62,2)=10775
540 BIN(63,1)=14350:BIN(63,2)=4875
550 TRAY(1,1)=0:TRAY(1,2)=16350
```

```
[illegible]
[illegible] GOTO 3850 'DO AGAIN
[illegible]
3982 '************************************************************
3984 '
3986 'CLEAR SCREEN
3988 '
3990 CLS:PRINT SPC(30);"EXECUTE PROCESS PLAN":PRINT"*************************
********************************************":RETURN
4000 '
4010 'CHECK FOR OPRERATOR INPUT
4020 '
4030 PRINT:PRINT:COLOR 4,0:PRINT"DO YOU WANT MAKE OPERATOR INPUT ? (YES IS ANY K
EY)"    :COLOR 7,0:PRINT
4040 ' FOR HOLD%=1 TO 500
4050 A$=INKEY$:IF A$ <> "" GOTO 4100 'INITIATE NEW PROCESS PLAN
4060 IF JOBSRUNG%=0 GOTO 4050
4070 'NEXT
4080 NEPROC%=0:RETURN 'NO NEW PROCESS
4090 '
4100 'GET OPERATOR INPUT
4110 '
4120 GOSUB 3990:PRINT:FILES "*.CON" 'CLEAR SCREEN
4130 PRINT:PRINT:PRINT "ENTER A PART NUMBER TO EXECUTE":PRINT SPC(TAB%);"(OR C T
O CANCEL)":PRINT SPC(TAB%);"(OR Q TO LEAVE EXECUTE ROUTINE AND RETURN TO MAIN ME
NU)":PRINT SPC(TAB%);"(OR F TO FIX A PROCESS WHERE THE MUX MISSED A FINISHED SIG
NAL)"
4140 PRINT:INPUT " ===>",ANSWER$
4150 IF ANSWER$="C" THEN RETURN ELSE IF ANSWER$="Q" THEN  EXITEXCT%=1:RETURN
 'DO EXITING COMMANDS
4160 IF ANSWER$="F" THEN PRINT:PRINT "ENTER NUMBER OF MACHINE FINISHED OR C TO C
ANCEL":PRINT SPC(TAB%);"(USE PROPER MACHINE CODE NUMBER OR PROGRAM WILL CRASH)":
INPUT " ===>",ANSWER$:IF ANSWER$="C" GOTO 4080 ELSE MFIX%=1
4170 IF MFIX%=1 THEN MACHINE%=VAL(ANSWER$):IF JOBSRUNG%(MACHINE%)=0 THEN PRINT"N
O JOBS RUNNING ON MACHINE":FOR HOLD%=1 TO 1000:NEXT:GOTO 4110 ELSE GOSUB 4570:RE
TURN 'EMEULATE A FINISHED SIGNAL (CNTRL-A) COMING IN FROM APPLE THAT MUX MISSED
4180 'INITIATE NEW PROCESS
4190 IF JOBSRUNG% = MAXJOBS% THEN PRINT:PRINT"MAXIMUM NUMBER JOBS OF";MAXJOBS%;"
IS ALREADY RUNNING":INPUT "TYPE RETURN TO CONTINUE",HOLD$:NEPROC%=0:RETURN 'MAX
NUMBER OF JOBS ALREADY RUNNING
4200 FOR COUNTER%=1 TO MAXJOBS%
4210 IF RSTATUS%(COUNTER%) = 0 THEN JOB%=COUNTER%:RSTATUS%(JOB%)=1:COUNTER%=MAXJ
OBS% 'SETS RUNNING STATUS FLAG
4220 NEXT
4230 PRTNUMB$(JOB%)=ANSWER$
4240 JOBSRUNG%=JOBSRUNG% + 1 'INCREMENT NUMBER OF JOBS RUNNING
4250 ON ERROR GOTO 4300
4260 OPEN "I",#JOB%,(PRTNUMB$(JOB%) + ".CON")
4270 NEPROC%=1 'SET NEW PROCESS FLAG
4280 ON ERROR GOTO 0
4290 RETURN
4300 'FILE DOESN'T EXIST
4310 PRINT:PRINT:PRINT"AN EXECUTABLE PROCESS PLAN FILE DOESN'T EXIST FOR PART NU
MBER  "PRTNUMB$(JOB%)
4320 PRINT:PRINT"TYPE A TO TRY AGAIN"
4330 ANSWER$=INKEY$:IF ANSWER$="" GOTO 4330
4340 IF ANSWER$="A" THEN RESUME 4100 'GET OPERATOR INPUT
4350 GOSUB 3990
4360 CLOSE #JOB%:JOBSRUNG%=JOBSRUNG% - 1:RSTATUS%(JOB%)=0:NEPROC%=0:RESUME 4370
'NO NEW PROCESS, RESET FLAGS, RESUME NECCESARY TO END ERROR TRAPPING ROUTINE
4370 RETURN
4380
4390 'CHECK FOR MACHINE FINISHED
4400 '
4410 PRINT"CHECKING FOR A MACHINE THAT FINISHED LAST PROCESS"
4420 'CHECK MUX FOR MACHINE FINISHED
```

```
4430 IF LOC(MUXF%) < 2 THEN PRINT #MUXF%,CHR$(1) + "0"; 'SEND DISCONNECT CURRENT
 SIGNAL IF NO MACHINE HAS FINISHED
4440 FOR HOLD%=1 TO 1500:NEXT 'WAIT TO FILL BUFFER
4450 IF LOC(MUXF%) < 2 THEN PRINT"NO MACHINES FINISHED":GOTO 4630 'NO MACHINES R
ECENTLY FINISHED
4460 MUX$=INPUT$(LOC(MUXF%),#MUXF%) 'GET MUX RESPONSE
4470 PRINT"MUX HAS ==>";MUX$
4480 FOR PORT%=1 TO 4
4490 PORT$=RIGHT$(STR$(PORT%),1)
4500 X=INSTR(MUX$,PORT$)
4510 IF X <> 0 GOTO 4550
4520 NEXT
4530 'IF FRSTCHECK%=1 THEN FRSTCHECK=0:GOTO 1250 'START SECOND CHECK OF MUX LOOK
ING FOR MACHINES
4540 GOTO 4630 'NO MACHINES RECENTLY FINISHED
4550 PRINT"MACHINE READY ON PORT ";PORT%
4560 ON PORT% GOSUB 4930,4930,4930,4930 'FIND MACHINE REQUESTING PORT
4570 IF MQPOINTER%(MACHINE%)=1 THEN JOB%=VAL(MACHINEQUE$(MACHINE%,MAXQUES%,1)) E
LSE JOB%=VAL(MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%) - 1,1)) 'FIND JOB WAS LAS
T WORKING ON
4580 MACHRDY%=1 'SET MACHINE READY FLAG
4590 NONEFIN%=0 'TURN OFF NO PROCESSES FINISHED FLAG
4600 JOBSRUNG%(MACHINE%)=0 'TURN OFF MACHINE BUSY FLAG
4610 RETURN
4620 '
4630 'CHECK FOR MACHINE QUE READY
4640 '
4650 STFCHECK%=QUECHECK%
4660 IF DEBUG%=2 THEN PRINT"QUECHECK% ==>";QUECHECK%
4670 IF MQPOINTER%(QUECHECK%) = MQNEXT%(QUECHECK%) GOTO 4780 'CHECK FOR WAITING
QUES
4680 IF JOBSRUNG%(QUECHECK%)=1 GOTO 4780 'MACHINE BUSY
4690 'A QUE IS READY AND MAYBE A MACHINE
4700 MACHINE%=QUECHECK%
4710 JOB%=VAL(MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),1))
4720 QUECHECK%=QUECHECK%+1 'SETUP TO CHECK NEXT MACHINE'S QUE AFTER THIS ONE
4730 NONEFIN%=1
4740 MACHRDY%=1
4750 PRINT "CHECKING QUE OF MACHINE";MACHINE%;" FOR EXECUTABLE PROCESS"
4760 RETURN
4770 '
4780 'MACHINE'S QUE EMPTY
4790 '
4800 QUECHECK%=QUECHECK%+1 'SETUP TO CHECK NEXT MACHINE'S QUE AFTER THIS ONE
4810 IF QUECHECK% > NUMBMACH% THEN QUECHECK% = 1
4820 IF STFCHECK% <> QUECHECK% GOTO 4670 'CHECK TO SEE IF HAVE CHECKED ALL MACHI
NES QUES
4830 'NO MACHINES OR JOBS ARE READY FOR NEXT PROCESS
4840 MACHRDY%=0
4850 RETURN
4860 '
4870 'TURN ON PORT
4880 PRINT #MUXF%,CHR$(1) + PORT$(MACHINE%); 'TURN ON PORT
4890 PRINT"PORT ";PORT$(MACHINE%);" TURNED ON"
4900 FOR HOLD%=1 TO 1500:NEXT:IF LOC(MUXF%)=0 THEN PRINT"HAVING PROBLEMS RECEIVI
NG FROM PORT ";PORT$(MACHINE%):GOTO 4900 'WAIT FOR BUFFER TO FILL WITH GARBAGE
4910 A$=INPUT$(LOC(MUXF%),#MUXF%) 'EMPTIES BUFFER
4920 RETURN
4930 '
4940 'ONE MACHINE PER PORT
4950 '
4960 IF PORT%=1 THEN MACHINE%=1 'STACKER
4970 IF PORT%=2 THEN MACHINE%=2 'MINI-ROBOT
4980 IF PORT%=3 THEN MACHINE%=4 'TOYO LATHE
4990 IF PORT%=4 THEN PRINT"ERROR IN PORT NUMBER"
5000 RETURN
```

```
5030 'NEXT PROCESS IN MACHINE QUE
5035
5040 IF NEWPROC%=1 THEN GOTO 5080 'STARTING NEW PROCESS
5050 IF MQPOINTER%(MACHINE%)=1 THEN PARAM%=MAXQUES% ELSE PARAM%=MQPOINTER%(MACHI
NE%) - 1 'FIND POSITION IN QUE OF LAST PROCESS EXECUTED
5060 IF VAL(MACHINEQUE$(MACHINE%,PARAM%,2)) = 0 THEN PRINT "NEXT PROCESS IS ALRE
ADY IN QUE":RETURN
5070 IF EOF(JOB%) THEN JOBSRUNG%=JOBSRUNG% - 1:RSTATUS%(JOB%)=0:CLOSE JOB%:MACHR
DY%=0:PRINT"FINISHED PROCESSING PART NUMBER ";PRTNUMB$(JOB%):RETURN 'PROCESS PLA
N FINISHED
5080 'GET NEXT PROCESS
5090 INPUT #JOB%,INLINE$ 'GET NEXT PROCESS
5100 INPUT #JOB%,EXTRACR1$ 'BLEED OFF EXTRA CARRIAGE RETURNS INSERTED BY DCLASS
5110 IF LEFT$(INLINE$,1)=" " THEN INLINE$=MID$(INLINE$,2):GOTO 5110 'STRIP LEADI
NG SPACES
5120 GOSUB 5400 'STRIPS NODE NUMBER INSERTED BY THE DCLASS MAINLINE
5130 'PRINT"NODE ==>";PARAM$
5140 GOSUB 5400:MACHINE%=VAL(PARAM$) 'GET MACHINE NUMBER
5150 PRINT"LOADING NEXT PROCESS FOR PART NUMBER ";PRTNUMB$(JOB%)
5160 IF HOLDING%(MACHINE%,JOB%,HJOB%)<>0 THEN SWAP HOLDING%(MACHINE%,JOB%,HQUE%)
, MQNEXT%(MACHINE%) 'PUT NEXT PROCESS IN QUE POSITIUN THAT WAS SAVED FOR IT
5170 MACHINEQUE$(MACHINE%,MQNEXT%(MACHINE%),1)=STR$(JOB%) 'SAVE JOB NUMBER WITH
PROCESS
5180 GOSUB 5400:PROCHOLD%=VAL(PARAM$) 'LOAD PROCESS HOLD FLAG FROM FILE
5190 MACHINEQUE$(MACHINE%,MQNEXT%(MACHINE%),2)=PARAM$
5200 'LOAD PROCESS PARAMETERS FROM CON FILE
5210 PRINT"JOB ";JOB%;" MACHINE";MACHINE%;" HOLD FLAG VALUE IS";PROCHOLD%
5220 FOR PARAM%=3 TO MQPARAMS%(MACHINE%) + 2 '1ST 2 POSITINS OF CON FILE ARE MAC
HINE NUMBER AND PROCESS HOLD FLAG.  THE FOLLOWING POSITIONS ARE FOR PARAMETERS F
OR THAT MACHINE
5230 IF PARAM% > 5 THEN INLINE$=EXTRACR1$ 'DCLASS INSERTS A LF AND CR AFTER THE
5TH PARAMTER IT OUTPUTS AND NEED TO GET AGAIN
5240 GOSUB 5400:MACHINEQUE$(MACHINE%,MQNEXT%(MACHINE%),PARAM%)=PARAM$
5250 PRINT"PARAM #";PARAM%-2;" IS ";MACHINEQUE$(MACHINE%,MQNEXT%(MACHINE%),PARAM
%)
5260 IF ASC(PARAM$) < 58 AND VAL(PARAM$)=0 THEN PARAM%=MQPARAMS%(MACHINE%) + 2 '
A PARAMTER OF ZERO SIGNALS NO MORE PARAMETERS FOLLOWING FUR THIS PROCESS
5270 IF VAL(MACHINEQUE$(MACHINE%,MQNEXT%(MACHINE%),PARAM%))=99 THEN WAITFLAG%=1:
WAITPOS%=PARAM%
5280 NEXT
5290 IF DEBUG% <> 0 THEN INPUT "TYPE RETURN TO CONTINUE",HOLD$
5300 IF HOLDING%(MACHINE%,JOB%,HJOB%)=1 THEN HOLDING%(MACHINE%,JOB%,HJOB%)=0 'TU
RN OFF FLAG THAT MACHINE IS HOLDING BECAUSE THE NEXT PROCESS WAS JUST LOADED FOR
 IT
5310 IF WAITFLAG%=1 THEN MACHHOLDING%=VAL(MACHINEQUE$(MACHINE%,MQNEXT%(MACHINE%)
,WAITPOS%+1)) 'FIND MACHINE WAITING FOR
5320 MQNEXT%(MACHINE%)=MQNEXT%(MACHINE%) + 1:IF MQNEXT%(MACHINE%) > MAXQUES% THE
N MQNEXT%(MACHINE%)=1
5330 IF WAITFLAG%=1 THEN MACHINEQUE$(MACHHOLDING%,MQNEXT%(MACHHOLDING%),1)=STR$(
JOB%):MACHINEQUE$(MACHHOLDING%,MQNEXT%(MACHHOLDING%),2)="99":MACHINEQUE$(MACHHOL
DING%,MQNEXT%(MACHHOLDING%),3)=STR$(MACHINE%):MACHINE%=MACHHOLDING%:WAITFLAG%=2:
GOTO 5320
5340 'ABOVE STATEMENT SAVES HOLD VALUE IN QUE AND THEN INCREMENTS QUE POINTER
5350 IF WAITFLAG%=2 THEN HOLDING%(MACHINE%,JOB%,HJOB%)=1:HOLDING%(MACHINE%,JOB%,
HQUE%)=MQNEXT%(MACHINE%):WAITFLAG%=0:GOTO 5320 'SAVE QUE POSITION OF NEXT PROCES
S FOR THE HELD MACHINE FROM THIS JOB AND THEN INCREMENT QUE POINTER TO LEAVE THE
 QUE EMPTY
5360 IF PROCHOLD%=0 THEN GOTO 5080 'IF PROCESS HOLD FLAG NOT SET THEN LOAD IN NE
XT PROCESS
5370 RETURN
5380 '
5390 'GET NEXT PARAMTER
5400 '
5410 PLEN%=INSTR(INLINE$," ")-1:IF PLEN%=-1 THEN PLEN%=LEN(INLINE$) 'FIND LENGTH
 OF PARAMTER AND ONLY FOR NO TRAILING SPACES
```

```
5420 PLINE$=MID$(INLINE$,1,PLEN%)
5430 INLINE$=MID$(INLINE$,PLEN%+1)
5440 IF LEFT$(INLINE$,1)=" " THEN INLINE$=MID$(INLINE$,2):GOTO 5440
5450 RETURN
5460 '
5470 'SEND MACHINE NEXT MOVE FROM QUE
5480 '
5490 IF JOBSRUNG%(MACHINE%)=1 THEN RETURN 'MACHINE BUSY
5500 IF MQPOINTER%(MACHINE%)=MQNEXT%(MACHINE%) THEN RETURN 'QUE IS EMPTY
5510 JOB%=VAL(MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),1))
5520 PRINT"SENDING MACHINE";MACHINE%;" IT'S NEXT PROCESS"
5530 GOSUB 4870 'TURN ON PORT.  IT IS NECESSARY TO TURN ON THE PORT OTHERWISE CA
N BE UNPREDICTABLE
5540 ON MACHINE% GOSUB 5580,6260,6840,6660 'SEND DATA TO MACHINE
5550 RETURN
5560 '
5570 '1 - STACKER
5580 'PARAM1 - OPERATION #,PARAM2 - BIN #, PARAM3 - TRAY #
5590 '
5600 OPERTN%=VAL(MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),3))
5610 BIN%=VAL(MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),4))
5620 TRAY%=VAL(MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),5))
5630 IF OPERTN% <> 1 GOTO 6020 ELSE IF BSTATUS%(BIN%) <> 1 AND TSTATUS%(TRAY%) <
> 1 GOTO 6020 'PROCESS CAN BE EXECUTED, BIN OR TRAY NOT IN USE
5640 PRINT "PROCESS FOR PART NUMBER ";PRTNUMB$(JOB%);" WAITING FOR A BIN OR TRAY
":PRINT"    THAT IT USES TO BECOME FREE."
5650 'CHECK QUES FOR RETURN BIN OPERATION
5660 STACKQUES%=ABS(MQNEXT%(MACHINE%)-MQPOINTER%(MACHINE%))-1 'GET NUMBER OF JOB
S IN STACKER QUE (-1 BECAUSE MQNEXT POINTS TO NEXT QUE TO BE FILLED
5670 FOR PARAM%=MQPOINTER%(MACHINE%)+1 TO STACKQUES%+MQPOINTER%(MACHINE%)
5680 IF PARAM% > MAXQUES% THEN PARAM%=1:WRAPPED% = 1
5690 IF DEBUG = 3 THEN PRINT"QUE==>";PARAM%;" COMMAND==>";MACHINEQUE$(1,PARAM%,3
)
5700 IF VAL(MACHINEQUE$(MACHINE%,PARAM%,3))=2 THEN RETQUE%=PARAM%:PARAM%=STACKQU
ES%+MQPOINTER%(MACHINE%):GOTO 5730 'CHECK QUE FOR A RETURN BIN COMMAND
5710 IF VAL(MACHINEQUE$(MACHINE%,PARAM%,3))=1 AND TSTATUS%(VAL(MACHINEQUE$(MACHI
NE%,PARAM%,5)))=0 THEN RETQUE%=PARAM%:PARAM%=STACKQUES%+MQPOINTER%(MACHINE%):GOT
O 5730 'CHECK QUE FOR A EXECUTABLE RETRIEVE BIN COMMAND
5720 IF WRAPPED%=1 AND PARAM%=MQNEXT%(MACHINE%) THEN PARAM%=STACKQUES%+MQPOINTER
%(MACHINE%)
5730 NEXT
5740 IF RETQUE%=0 THEN PRINT"NO RETURN BIN OPERATIONS FOUND":RETURN
5750 'SHUFFLE QUES UP AND PUT RETURN BIN QUE IN CURRENT QUE POSITION
5760 'MOVE QUE WITH RETURN BIN COMMAND TO TEMPORARY STORAGE
5770 IF DEBUG%=3 THEN PRINT"RETQUE==>";RETQUE%
5780 FOR PARAM%=1 TO MQPARAMS%(MACHINE%)+2
5790    TEMP$(PARAM%)=MACHINEQUE$(MACHINE%,RETQUE%,PARAM%)
5800 IF DEBUG%=3 THEN PRINT"TEMP";PARAM%;"==>";TEMP$(PARAM%)
5810 NEXT
5820 QUE%=RETQUE%:RETQUE%=0
5830 LQUE%=QUE%-1 'FIND NEXT LOWER QUE
5840 IF LQUE% < 1 THEN LQUE%=MAXQUES% 'CHECK FOR WRAP AROUND
5850 IF DEBUG%=3 THEN PRINT"MOVED QUE==>";LQUE%
5860 FOR PARAM%=1 TO MQPARAMS%(MACHINE%)+2
5870    MACHINEQUE$(MACHINE%,QUE%,PARAM%)=MACHINEQUE$(MACHINE%,LQUE%,PARAM%)
5880 IF DEBUG%=3 THEN PRINT"PARAM==>";MACHINEQUE$(1,QUE%,PARAM%)
5890 NEXT
5900 IF DEBUG%=3 THEN PRINT"MQPOINTER%==>";MQPOINTER%(1)
5910 IF LQUE%=MQPOINTER%(MACHINE%) GOTO 5960
5920 IF QUE%=1 THEN QUE%=MAXQUES% ELSE QUE%=QUE%-1
5930 LQUE%=LQUE%-1
5940 GOTO 5830 'MOVE NEXT QUE
5950 '
5960 'MOVE QUE WITH RETURN BIN COMMAND TO CURRENT QUE POSITION
5970 FOR PARAM%=1 TO MQPARAMS%(MACHINE%)+2
5980    MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),PARAM%)=TEMP$(PARAM%)
```

```
[illegible]
6000 [illegible] 'EXECUTE QUE WITH RETURN BIN COMMAND
[illegible]
6020 PRINT #MUXF%,READY$; 'TELL APPLE READY
6030 FOR HOLD%=1 TO 2000:NEXT:IF LOC(MUXF%)=0 THEN GOTO 6030 'WAIT FOR BUFFER TO
 FILL UP WITH GARBAGE
6040 ANSWER$=INPUT$(LOC(MUXF%),#MUXF%):X=INSTR(ANSWER$,'READY'):IF X=0 THEN PRIN
T'DIDN'T RECEIVE READY FROM STACKER':GOTO 6020
6050 PRINT #MUXF%,OPERTN%;CHR$(10);
6060 INPUT #MUXF%,ANSWER$:PRINT'OPERTION SENT TO APPLE IS ';ANSWER$
6070 X=INSTR(ANSWER$,RIGHT$(STR$(OPERTN%),1)):IF X = 0 THEN PRINT #MUXF%,BAD$;:G
OTO 6050
6080 PRINT #MUXF%,OK$;
6090 PRINT #MUXF%,BIN%;CHR$(10);
6100 INPUT #MUXF%,ANSWER$:PRINT'BIN # SENT TO APPLE IS ';ANSWER$
6110 X=INSTR(ANSWER$,RIGHT$(STR$(BIN%),1)):IF X = 0 THEN PRINT #MUXF%,BAD$;:GOTO
 6090
6120 PRINT #MUXF%,OK$;
6130 PRINT #MUXF%,TRAY%;CHR$(10);
6140 INPUT #MUXF%,ANSWER$:PRINT'TRAY IS ';ANSWER$
6150 X=INSTR(ANSWER$,RIGHT$(STR$(TRAY%),1)):IF X = 0 THEN PRINT #MUXF%,BAD$;:GOT
O 6140
6160 PRINT #MUXF%,OK$;
6170 JOBSRUNG%(MACHINE%)=1 'SETS MACHINE BUSY FLAG
6180 IF OPERTN%=2 THEN BSTATUS%(BIN%)=0:TSTATUS%(TRAY%)=0:JSTATUS%(MACHINE%,TRAY
%)=VAL(MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),1)) 'FOR RETURN OPERATION RECOR
D BIN, TRAY, AND JOB STATUS AS AVAILABLE
6190 IF OPERTN%=1 THEN BSTATUS%(BIN%)=1:TSTATUS%(TRAY%)=1:JSTATUS%(MACHINE%,TRAY
%)=VAL(MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),1))
6200 MQPOINTER%(MACHINE%)=MQPOINTER%(MACHINE%) + 1
6210 IF MQPOINTER%(MACHINE%) > MAXQUES% THEN MQPOINTER%(MACHINE%)=1
6220 PRINT #MUXF%,CHR$(1) + '0'; 'IT IS NECESSARY TO DISCONNECT FROM THE MUX BEC
AUSE IF IT DOESN'T SEND THE PORT NUMBER SOMETIMES IF IT IS ALREADY CONNECTED TO
THE PORT WHEN THE APPLE SENDS A ATTENTION REQUEST SIGNAL (CTRL-A)
6230 RETURN
6240 '
6250 '2 - MINI ROBOT
6260 'PARAM1 - FILE NAME, PARAM2 AND 3 - MACHINES USED BY FILE
6270 '
6280 PARAM%=4:MACH%=1
6290 MACH%=VAL(MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),PARAM%)):PARAM%=PARAM%
+ 1 '1ST MACHINE NEXT EXECUTION FILE IS DEPENDANT ON
6300 IF MACH%=0 THEN GOTO 6360 'NOT DEPENDANT ON ANY OTHER MACHINES
6310 IF MACH%=1 THEN TRAY%=VAL(MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),PARAM%)
):IF JSTATUS%(1,TRAY%) <> JOB% THEN PRINT'ROBOT WAITING FOR STACKER TRAY #';TRAY
%:RETURN:ELSE PARAM%=PARAM% + 1:GOTO 6340 'CHECK TO SEE IF STACKER IS READY
6320 IF MACH%=99 THEN WAITMACH%=VAL(MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),PA
RAM%)):PARAM%=PARAM%+1:GOTO 6340
6330 IF JSTATUS%(MACH%,1) <> JOB% THEN PRINT'ROBOT WAITING FOR MACHINE #';MACH%:
 RETURN 'MACHINE NOT TO THIS JOB YET
6340 IF MACH%=1 THEN MACH%=2:GOTO 6290 'CHECK FOR TO SEE IF SECOND MACHINE DEPEN
DANT ON IS READY
6350 IF WAITMACH% <> 0 THEN IF HELD%(WAITMACH%) <> JOB% THEN PRINT'ROBOT WAITING
 FOR MACHINE';WAITMACH%:RETURN ELSE WAITMACH%=0 'CHECK IF MACHINE ROBOT WAITING
FOR IS HELD ON THIS JOB
6360 ' EXECUTE PROCESS
6370 PRINT #MUXF%,'READY';CHR$(13);
6380 FOR HOLD%=1 TO 4000:NEXT:IF LOC(MUXF%)=0 GOTO 6380 'WAIT FOR APPLE TO SEND
RESPONSE THROUGH MUX
6390 ANSWER$=INPUT$(LOC(MUXF%),#MUXF%):X=INSTR(ANSWER$,'OK'):IF X=0 THEN PRINT'H
AVING PROBLEMS SENDING TO APPLE - ROBOT':GOTO 6370
6400 PRINT'APPLE ACCEPTED FIRST READY'
6410 FOR HOLD%=1 TO 1000:NEXT:PRINT #MUXF%,'1';CHR$(13); 'WAIT FOR APPLE AND THE
N CHOOSE EXECUTE OPTION
6420 FOR HOLD%=1 TO [illegible]:NEXT 'WAIT FOR APPLE TO BE READY
6430 ' LOAD APPLE FILE TO EXECUTE
```

```
6440 PRINT #MUXF%,"READY";CHR$(13);:PRINT"SENT SECOND READY"
6450 FOR HOLD%=1 TO 500:NEXT:IF LOC(MUXF%)=0 GOTO 6450
6460 ANSWER$=INPUT$(LOC(MUXF%),#MUXF%)
6470 X=INSTR(ANSWER$,"OK"):IF X=0 THEN PRINT"HAVING PROBLEMS RECEIVING FROM APPL
E - ROBOT":GOTO 6440
6480 FOR HOLD%=1 TO 1000:NEXT
6490 PRINT #MUXF%,MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),3);CHR$(13); 'SEND R
OBOT FILE NAME TO EXECUTE
6500 PRINT"SENT FILE NAME"
6510 FOR HOLD%=1 TO 2000:NEXT:IF LOC(MUXF%)=0 THEN PRINT"HAVING PROBLEMS RECEIVI
NG FILE NAME BACK FROM APPLE - ROBOT":GOTO 6510
6520 ANSWER$=INPUT$(LOC(MUXF%),#MUXF%):PRINT"APPLE SENT ==>";ANSWER$:X=INSTR(ANS
WER$,MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),3)):IF X=0 THEN PRINT"APPLE HAVIN
G PROBLEMS RECEIVING ROBOT CONTROL FILE NAME":PRINT #MUXF%,"BAD";CHR$(13);:GOTO
6490
6530 PRINT #MUXF%,"OK";CHR$(13);
6540 FOR HOLD%=1 TO 5000:NEXT:IF LOC(MUXF%)=0 GOTO 6570 'WAIT FOR APPLE TO ATTEM
PT TO USE CONTROL FILE PASSED
6550 ANSWER$=INPUT$(LOC(MUXF%),#MUXF%)
6560 X=INSTR(ANSWER$,"BAD"):PRINT"APPLE SENT ==>",ANSWER$:IF X<>0 THEN PRINT"ROB
OT COULD NOT FIND ":PRINT"FILE ";MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),3);"
FOR PART NUMBER ";PRTNUMB$(JOB%):PRINT:INPUT"TYPE RETURN TO CONTINUE ";HOLD$:GOT
O 6610
6570 PRINT #MUXF%,CHR$(1);"0"; 'DISCONNECT MUX FROM ROBOT
6580 RSTATUS%(MACHINE%)=1 'SET ROBOT BUSY FLAG
6590 JOBSRUNG%(MACHINE%)=1 'SET ROBOT BUSY FLAG
6600 JSTATUS%(MACHINE%,1)=JOB% 'JOB ROBOT CURRENTLY WORKING ON
6610 MQPOINTER%(MACHINE%)=MQPOINTER%(MACHINE%) + 1
6620 IF MQPOINTER%(MACHINE%) > MAXQUES% THEN MQPOINTER(MACHINE%)=1
6630 RETURN
6640 '
6650 '4 - TOYO LATHE
6660 'PARAM1 - FILE NAME,PARAM2 - FILE EXTENSION, PARAM3 - ROBOT IS DEPENDANT ON
 (MACHINE 2 OR 3)
6670 '
6680 IF JOB% <> 0 THEN IF HOLDING%(MACHINE%,JOB%,HJOB%) <> 0 AND MACHINEQUE$(MAC
HINE%,MQPOINTER%(MACHINE%),2) = "99" THEN HELD%(MACHINE%)=JOB%:PRINT"LATHE IS BE
ING HELD IDLE BY MACHINE ";MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),3):RETURN
6690 IF MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),2)="99" THEN GOSUB 6820 'HOLDI
NG FLAG QUE SKIPPED
6700 MACH1%=VAL(MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),4))
6710 IF MACH1% <> 0 THEN IF JSTATUS%(MACH1%,1) <> JOB% THEN RETURN 'NOT DEPENDAN
T ON ROBOT OR ROBOT NOT REACHED THIS JOB YET
6720 PRINT #MUXF%,READY$;
6730 FOR HOLD%=1 TO 2000:NEXT:IF LOC(MUXF%)=0 THEN PRINT"HAVING PROBLEMS RECEIVI
NG FROM APPLE":GOTO 6720 'WAIT FOR BUFFER TO FILL
6740 ANSWER$=INPUT$(LOC(MUXF%),#MUXF%):X=INSTR(ANSWER$,"READY"):IF X=0 THEN PRIN
T"DIDN'T RECEIVE READY FROM LATHE":GOTO 6720
6750 PRINT #MUXF%,"EXECUTE" + CHR$(10); 'SELECT EXECUTE LATHE FILE FILE OPTION
6760 INPUT #MUXF%,ANSWER$:X=INSTR(ANSWER$,"OK"):IF X=0 THEN PRINT"LATHE DIDN'T T
AKE EXECUTE":GOTO 6750
6770 LFILE$=MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),3) + "." + MACHINEQUE$(MAC
HINE%,MQPOINTER%(MACHINE%),4)
6780 PRINT #MUXF%,LFILE$;CHR$(10); 'SEND LATHE FILE NAME TO EXECUTE
6790 PRINT #MUXF%,CHR$(1);"0"; 'IT IS NECESSARY TO DISCONNECT FROM THE MUX OR EL
SE MULTIPLEXOR DOESN'T NOTICE WHEN THE APPLE SENDS A ATTENTION REQUEST CHARACTER
 (CTRL-A)
6800 JOBSRUNG%(MACHINE%)=1 'SET MACHINE BUSY FLAG
6810 JSTATUS%(MACHINE%,1)=VAL(MACHINEQUE$(MACHINE%,MQPOINTER%(MACHINE%),1)) 'REC
ORDS WHICH JOB LATHE IS WORKING ON
6820 MQPOINTER%(MACHINE%)=MQPOINTER%(MACHINE%) + 1:IF MQPOINTER%(MACHINE%) > MAX
QUES% THEN MQPOINTER%(MACHINE%)=1 'INC MACHINE QUE POINTER
6830 RETURN
6840 RETURN
```

```
10 REM  ******************************************
20 REM  *  STORAGE AND RETRIEVAL SYSTEM CONTROLLER
30 REM  *          -BYU MINI-CAM LAB-
40 REM  *   ORIGINAL APPLESOFT VERSION BY DAVE JESPERSON
50 REM  *    MICROSOFT PROGRAM BY JUSTIN REDD
60 REM  *    OCTOBER, 1983
64 REM *
66 REM *  MODIFIED IN JUNE OF 84 TO WORK UNDER CONTROL LOF GREG PETO'S PROGRAMS
70 REM  *
80 REM  *   WHEN RUN, THIS PROGRAM WILL WAIT FOR 3
90 REM  *   PARAMETERS TO BE PASSED TO IT THROUGH
100 REM *   THE RS232 LINK.  THESE THREE PARAMETERS
110 REM *   ARE DEFINED AS THE OPERATION#,BIN#,AND
120 REM *   TRAY#.  OPERATION# 0 = RETURN BIN
130 REM *           OPERATION# 1 = RETRIEVE BIN
140 REM *           OPERATION# 2 = QUIT PROGRAM
150 REM *
160 REM *   TO RUN THIS PROGRAM CYDRIVER.HEX AND COMM.HEX
170 REM *   MUST BE LOADED INTO MEMORY.
180 REM *
190 REM *******************************************
200 REM
210 HOME:PRINT "           APPLE STACKER PROGRAM":PRINT:PRINT"------------------
----------------------------------"
220 PRINT:PRINT
230 REM **************************
240 REM * LOAD CYDRIVER AND COMM
250 REM **************************
260 REM
270 CALLER$="STACKIBM.CON":CLINE=300:PRGM$="XXXX":SLINE=999:HFILE$="XXXX"
280 COMMON CALLER$,CLINE,PRGM$,SLINE,HFILE$
290 CHAIN "LOADASM.BAS"
300 REM
310 REM **************************
320 REM * INITIALIZE
330 REM **************************
334 READY$="READY" + CHR$(13)
335 BAD$="BAD" + CHR$(13)
336 OK$="OK" + CHR$(13)
338 DONE$=CHR$(1) 'MUX INTERUPT REQUEST SIGNAL
340 REM
350 DIM BIN(63,2)
360 DIM TRAY(2,2)
370 BIN(11,1)=4085:BIN(11,2)=16375
380 BIN(12,1)=4138:BIN(12,2)=10750
390 BIN(13,1)=4138:BIN(13,2)=4925
400 BIN(21,1)=6140:BIN(21,2)=16375
410 BIN(22,1)=6140:BIN(22,2)=10675
420 BIN(23,1)=6212:BIN(23,2)=4775
430 BIN(31,1)=8200:BIN(31,2)=16375
440 BIN(32,1)=8269:BIN(32,2)=10775
450 BIN(33,1)=8262:BIN(33,2)=4875
460 BIN(41,1)=10250:BIN(41,2)=16375
470 BIN(42,1)=10300:BIN(42,2)=10750
480 BIN(43,1)=10312:BIN(43,2)=4925
490 BIN(51,1)=12287:BIN(51,2)=16375
```

```
500 BIN(52,1)=12312:BIN(52,2)=10800
510 BIN(53,1)=12344:BIN(53,2)=4850
520 BIN(61,1)=14320:BIN(61,2)=16375
530 BIN(62,1)=14337:BIN(62,2)=10775
540 BIN(63,1)=14350:BIN(63,2)=4875
550 TRAY(1,1)=0:TRAY(1,2)=16350
560 TRAY(2,1)=2025:TRAY(2,2)=16350
570 REM
580 CY$="I,R 253,S 1,F 1,A,P 1,P 0"
585 MOTOR1$="I,R 251,S 1,F 1,A,P 1,P 0"
586 MOTOR1$=MOTOR1$+""
590 CY$=CY$+""
600 CY1$="XXX"+"":CY2$="XXX"+"":CY3$="XXX"+""
610 FOR I = 1 TO 2
620 Q$=USR1(MOTOR1$)
630 Q$=USR2(CY$)
640 Q$=USR3(CY$)
650 NEXT I
660 REM
670 REM ****************************
680 REM * SET HOOK BACK 1 INCH
690 REM ****************************
700 REM
710 CY$="N 3000,-,G,A" 'MOVE HOOK OUT AN INCH AND A 1/8,SET AS AT HOME POSITION
715 MOTOR2$="N 16795,-,G,A"
716 Q$=USR2(MOTOR2$)
730 Q$=USR3(CY$)
741 GOSUB 2190 'SET HOOK BACK ONE INCH
742 'WAIT FOR READY SIGNAL FROM IBM
745 Q$=USR8(IBM$)
746 X=INSTR(IBM$,"READY"):IF X = 0 THEN Q$=USR7(BAD$):PRINT"RECEIVED ==>";IBM$:G
OTO 745
747 Q$=USR7(READY$):PRINT"RECEIVED READY"
750 REM
760 REM ****************************
770 REM * INPUT PARAMETERS FROM IBM
780 REM ****************************
790 REM
800 Q$="XXX" + "":OPERATION$="XXX"+"":XBIN$="XXX"+"":XTRAY$="XXX"+""
810 'OK$="OK"+CHR$(13):WHAT$="WHAT?"+CHR$(13):READY$="READY"+CHR$(13)
815 'Q$=USR7(READY$)
820 PRINT "OPERATION# = ";
840 Q$=USR8(OPERATION$):PRINT OPERATION$
842 ANSWER$=OPERATION$ + CHR$(13)
844 Q$=USR7(ANSWER$)
846 Q$=USR8(CHECK$):X=INSTR(CHECK$,"OK"):IF X=0 THEN GOTO 840 'APPLE DIDN'T RECE
IVE OPERATION CORRECTLY"
850 'IF OPERATION$ <> "0" AND OPERATION$ <> "1" AND OPERATION$ <> "2" THEN PRINT
  "INVALID OPERATION#":Q$=USR7(WHAT$):PRINT:GOTO 820
860 OPERATION = VAL(OPERATION$)
870 IF OPERATION = 3 THEN GOTO 1470
880 'Q$=USR7(OK$)
890 PRINT "BIN# = ";
900 Q$=USR8(XBIN$):PRINT XBIN$
902 ANSWER$=XBIN$ + CHR$(13)
904 Q$=USR7(ANSWER$)
```

```
906 Q$=USR8(CHECK$):X=INSTR(CHECK$,"OK"):IF X=0 THEN GOTO 900
910 'DATA 11,12,13,21,22,23,31,32,33,41,42,43,51,52,53,61,62,63
920 'FOR I = 1 TO 18
930 'READ X
940 'IF VAL(XBIN$)=X THEN RESTORE: GOTO 1000
970 'NEXT I
980 'RESTORE:Q$=USR7(WHAT$):PRINT "BAD BIN#":PRINT:GOTO 890
1000 XBIN=VAL(XBIN$)
1005 'Q$=USR7(OK$)
1010 PRINT "TRAY# = ";
1020 Q$=USR8(XTRAY$):PRINT XTRAY$
1022 ANSWER$=XTRAY$ + CHR$(13)
1024 Q$=USR7(ANSWER$)
1025 'IF XTRAY$ <> "1" AND XTRAY$ <> "2" THEN PRINT "BAD TRAY#":PRINT:Q$=USR7(WH
AT$):GOTO 1010
1026 Q$=USR8(CHECK$):X=INSTR(CHECK$,"OK"):IF X=0 THEN GOTO 1020
1030 XTRAY=VAL(XTRAY$)
1040 PRINT:PRINT "------------------------------":PRINT
1050 REM
1060 REM ***************************
1070 REM * GOTO OPERATION# ROUTINE
1080 REM ***************************
1090 REM
1100 'IF XTRAY < > 1 AND XTRAY < > 2 THEN PRINT "BAD TRAY# PASSED":GOTO 760
1110 'IF XBIN > 63 OR XBIN < 11 THEN PRINT "BAD BIN# PASSED":GOTO 760
1120 N$=RIGHT$(STR$(XBIN),1)
1130 'IF N$ <> "1" AND N$ <>"2" AND N$ <> "3" THEN PRINT "BAD BIN# PASSED":GOTO
760
1140 ON OPERATION GOTO 1310,1150 '1-RETRIEVE BIN,2-RETURN BIN
1150 REM ***************************
1160 REM * RETURN BIN
1170 REM ***************************
1180 REM
1190 GOSUB 1730
1200 GOSUB 1860
1210 FLAG$="TRAY"
1220 GOSUB 1960
1230 GOSUB 2270
1240 GOSUB 1620
1250 GOSUB 1860
1260 FLAG$="BIN"
1270 GOSUB 2070
1280 GOSUB 2170
1284 Q$=USR7(DONE$)
1286 PRINT"SENT FINISHED SIGNAL"
1290 GOTO 742 'WAIT FOR IBM READY SIGNAL
1300 REM
1310 REM ***************************
1320 REM * RETRIEVE BIN
1330 REM ***************************
1340 REM
1350 GOSUB 1620
1360 GOSUB 1860
1370 FLAG$="BIN"
1380 GOSUB 1960
1390 GOSUB 2270
```

```
1400 GOSUB 1730
1410 GOSUB 1860
1420 FLAG$="TRAY"
1430 GOSUB 2070
1440 GOSUB 2170
1444 Q$=USR7(DONE$)
1448 PRINT"SENT FINISHED SIGNAL"
1450 GOTO 742 'WAIT IBM READY SIGNAL
1460 REM
1470 REM ***************************
1480 REM * TERMINATE PROGRAM
1490 REM ***************************
1500 REM
1510 CY1$="P 0":CY2$="P 16795":CY3$="P 0"
1520 FOR I= 1 TO 2
1530 Q$=USR1(CY1$)
1540 Q$=USR2(CY2$)
1550 NEXT I
1560 FOR I = 1 TO 2
1570 REMQ$=USR3(CY3$)
1580 NEXT I
1590 HOME:PRINT "STACKER PROGRAM TERMINATED"
1600 PRINT:PRINT:END
1610 REM
1620 REM ***************************
1630 REM * GOTO BIN COODINATES
1640 REM ***************************
1650 REM
1660 CY1$="P" + STR$(BIN(XBIN,1))
1670 IF OPERATION = 1 THEN CY2$="P" + STR$( BIN(XBIN,2) + 385 )
1680 IF OPERATION = 2 THEN CY2$="P" + STR$( BIN(XBIN,2) )
1690 FOR I = 1 TO 2
1700 Q$=USR1(CY1$):Q$=USR2(CY2$)
1710 NEXT I
1720 RETURN
1730 REM
1740 REM ***************************
1750 REM * GOTO TRAY COORDINATES
1760 REM ***************************
1770 REM
1780 CY1$="P" + STR$(TRAY(XTRAY,1))
1790 IF OPERATION = 1 THEN CY2$="P" + STR$(TRAY(XTRAY,2))
1800 IF OPERATION = 2 THEN CY2$="P" + STR$( TRAY(XTRAY,2) + 385 )
1810 FOR I = 1 TO 2
1820 Q$=USR1(CY1$):Q$=USR2(CY2$)
1830 NEXT I
1840 RETURN
1850 REM
1860 REM ***************************
1870 REM * HOOK FORWARD
1880 REM ***************************
1890 REM
1900 CY3$="P 0"
1910 FOR I = 1 TO 2
1920 Q$=USR3(CY3$)
1930 NEXT I
```

```
1940 RETURN
1950 REM
1960 REM ***************************
1970 REM * ENGAGE HOOK
1980 REM ***************************
1990 REM
2000 IF FLAG$ = "BIN" THEN CY2$="P" + STR$( BIN(XBIN,2) )
2010 IF FLAG$ = "TRAY" THEN CY2$="P" + STR$( TRAY(XTRAY,2) )
2020 FOR I = 1 TO 2
2030 Q$=USR2(CY2$)
2040 NEXT I
2050 RETURN
2060 REM
2070 REM ***************************
2080 REM * DISENGAGE HOOK
2090 REM ***************************
2100 REM
2110 IF FLAG$="BIN" THEN CY2$="P" + STR$( BIN(XBIN,2) + 385 )
2120 IF FLAG$="TRAY" THEN CY2$="P" + STR$( TRAY(XTRAY,2) + 385 )
2130 FOR I = 1 TO 2
2140 Q$=USR2(CY2$)
2150 NEXT I
2160 RETURN
2170 REM
2180 REM ***************************
2190 REM * HOOK BACK ONE INCH
2200 REM ***************************
2210 REM
2220 CY3$="P 1600"
2230 FOR I = 1 TO 2
2240 Q$=USR3(CY3$)
2250 NEXT I
2260 RETURN
2270 REM
2280 REM ***************************
2290 REM * HOOK ALL THE WAY BACK
2300 REM ***************************
2310 REM
2320 CY3$="P 16000"
2330 FOR I = 1 TO 2
2340 Q$=USR3(CY3$)
2350 NEXT I
2360 RETURN
2370 REM
```

```
100 '**********************************
110 '* PART PROCESS TEXT FILE GENERATOR
120 '*         FOR THE LATHE
130 '*  APPLESOFT PROGRAM BY PAUL SMITH
140 '*      REWRITTEN FOR MBASIC BY
150 '*          GREGORY J. PETO
160 '*            JUNE OF 1984
162 '*
164 '* TO CHAIN TO THIS PROGRAM FOR USE UNDER IBM CONTROL SET OPTION1 TO 2 WITH
A COMMON STATEMENT FIRST
165 '*
166 '* THIS PROGRAM GENERATES A STANDARD FORMAT CNC FILE THAT CAN THEN
167 '* BE USED WITH THE INTERPRETER TO DRIVE THE LATHE.  THE DATA IT NEEDS
168 '* CAN BE DOWNLOADED FROM THE IBM MASTER CONTROLLER PROGRAM OR THE
169 '* PROGRAM WILL PROMPT FOR THE INFORMATION.  IT ONLY SUPPORTS
170 '* PART FAMILIES A00 - A20
172 '*
174 '**********************************
180 '
182 '* INITIALIZE COMMUNICATION SUBROUTINES *
183 HOME
184 '
186 CALLER$="LTEXT.GEN":CLINE=300:PRGM$="XXXX":SLINE=999:HFILE$="XXXX" 'SET UP T
O RETURN TO THIS PROGRAM PARAMETERS
188 CHAIN "B:LOADASM",,ALL
300 '
310 '********** MAIN PROGRAM **********
320 '
330 GOSUB 480 'INITIALIZE ARRYS AND CONSTANTS
332 '
340 IF OPTION1 <> 3 THEN GOSUB 1350 'GET MODE OF OPERATION
342 '
350 GOSUB 1520 'GET DATA TO DESCRIBE PART
352 '
360 IF OPTION1 = MANUAL GOTO 420 'MANUAL PROGRAMING GOES DIRECTLY TO STORE DATA
362 '
370 GOSUB 3770 'DO INITIAL LATHE CALC'S
380 GOSUB 3910 'DO ROUGH FACE OF RIGHT END
390 GOSUB 4150 'DO ROUGH CUT
400 GOSUB 4630 'DO FINISH CUT
410 GOSUB 4930 'DO CUTOFF
420 GOSUB 5230 'STORE DATA
421 '
422 IF CALLER1$ <> "" THEN CHAIN CALLER1$
430 GOTO 340 'GET MODE AND START AGAIN
432 '
440 '**********************************
450 '
460 '* INITIALIZE ARRAYS AND CONSTANTS
470 '
480 HOME:PRINT"INITIALIZING VARIABLES"
490 ANSWER$ = ".51ANSWER = 0:PSTN = 1 'THIS PUTS OFTEN USED VARIABLES AT FRONT
 OF LIST
500 OPTION BASE 1 'ARRAY PARAMTERS START AT 1 NOT 0
510 'ALL ARRAYS ARE INITIALIZED WITH 0 AUTOMATICALLY
520 DIM MOVE$(200) 'SETS MAX MOVES. EACH MEMBER OF THIS ARRAY WILL HOLD A LINE O
```

```
520 DIM MOVE$(200) 'SETS MAX MOVES. EACH MEMBER OF THIS ARRAY WILL HOLD A LINE O
F THE FINAL TEXT FILE CREATED
530 DIAMAX = 5 'MAX NUMBER OF DISTINCT DIAMETERS
540 DIM DMENSION(DIAMAX,2) 'FOR EACH DIAMETER THIS WILL HOLD 2 PARAMETERS- WIDTH
 AND LENGTH
550 WDTH = 1 'USED WITH DMENSION ARRAY
560 LENGTH = 2 'USED WITH DMENSIONS ARRAY
570 DIM OFFSET(DIAMAX) 'WILL HOLD OFFSET FROM LEFT END FOR EACH DIAMETER
580 COUNT = 1 'USED TO SPECIFY THE CURRENT MOVE NUMBER
582 MAXCUT = .01 'MAXIMUM CUT DEPTH IN ONE PASS
590 MINFEED = 3 'MINIMUM FEEDRATE
592 MAXFEED = 10 'MAXIMUM FEEDRATE
593 MINLEN = .075 'MINIMUM LENGTH OF ANY SINGLE DIAMETER
594 MAXDIAM = .5 'MAX STOCK DIAMETER
595 MAXLEN = 4 'MAX STOCK LENGTH IN INCHES
596 MAXZ = 4 'MAA00EG16720RT1#0903809038G903809038020193T
598 MAXX = -2 'MAX MOVEMENT AWAY FROM CENTER
600 STP$ = "M02" 'COMMAND TO STOP LATHE
610 TOOL$ = "M06" 'COMMAND TO STOP FOR TOOL CHANGE
640 RAPID = 50 'RAPID TRANSVERSAL FEEDRATE
650 SHORT = 30 'SHORT MOVE FEEDRATE -USED ONLY WHEN NOT CUTTING
654 CUTOFFSPEED = 1.7 'CUT OFF FEEDRATE - SLOWEST FEEDRATE ALLOWABLE
660 CLRNC = .025 'CLEARANCE OF CUTTING TOOL FROM SURFACE FOR MOVES
670 FUDGE = .01 'FUDGE FACTOR USED IN CUTOFF
680 READY$="R" + CHR$(13)
682 EROR$="E" + CHR$(13)
700 '
710 '**** VERIFY VARIABLE CONSTANTS ****
720 '
730 CHANGE = 0
740 OPEN "I",#1,"LCONST"
750 INPUT #1,TOOL1CENT 'TOOL 1 OFFSET FROM CENTER LINE WHEN LATHE IS INITIALIZED
760 INPUT #1,TOOL1FACE 'TOOL 1 OFFSET FROM CHUCK FACE WHEN LATHE IS INITIALIZED
770 INPUT #1,TOOL2CENT
780 INPUT #1,TOOL2FACE
790 INPUT #1,CUTWIDTH 'WIDTH OF CUTOFF TOOL
800 INPUT #1,RS232 'SLOT NUMBER OF RS232 CARD
810 INPUT #1,DISKSLOT 'SLOT NUMBER OF DISK DRIVE OR HARD DISK
811 CLOSE
812 'DISPLAY CONSTANTS
813 IF OPTION1 = 3 THEN RETURN
820 WIDTH,24 :HOME:PRINT SPC(7);"CONSTANTS USED IN PROGRAM":NUMB = 1
830 PRINT"*******************************************"
832 TAB1 = 5
840 PRINT NUMB;". OFFSET ROUGH CUT TOOL FROM":PRINT SPC(TAB1);"CENTER LINE = ";S
R$(TOOL1CENT);" INCHES.":NUMB = NUMB + 1
 50 PRINT NUMB;". OFFSET ROUGH CUT TOOL FROM":PRINT SPC(TAB1);"CHUCK FACE = ";ST
$(TOOL1FACE);" INCHES":NUMB = NUMB + 1
 60 PRINT NUMB;". OFFSET CUTOFF TOOL FROM":PRINT SPC(TAB1);"CENTER LINE = ";STR$
TOOL2CENT);" INCHES.":NUMB = NUMB + 1
 70 PRINT NUMB;". OFFSET CUTOFF TOOL FROM":PRINT SPC(TAB1);"CHUCK FACE = ";STR$(
OOL2FACE);" INCHES":NUMB = NUMB + 1
 80 PRINT NUMB;". WIDTH OF CUTOFF TOOL = ";STR$(CUTWIDTH);" INCHES":NUMB = NUMB
 1
 90 PRINT NUMB;". RS232 CARD IS IN SLOT #";STR$(RS232):NUMB = NUMB + 1
 00 PRINT NUMB;". DISK DRIVE CARD IS IN SLOT #";STR$(DISKSLOT)
```

```
908 PSTN = 23 - 5 'POSTITION TO START INPUT LINE
910 VTAB(PSTN): PRINT "DO YOU WISH TO CHANGE ANY":PRINT "OF THESE (Y/N) ? ";:GET
 ANSWER$:PRINT
920 IF ANSWER$ = "N" AND CHANGE = 0 THEN RETURN 'NO CHANGES
930 IF ANSWER$ = "N" THEN HOME:PRINT"SAVING CHANGES":GOSUB 1230:RETURN 'SAVES PR
IOR CHANGES AND THEN EXITS
940 IF ANSWER$ <> "Y" THEN :PRINT:PRINT"TYPE ONLY Y OR N":GOTO 910 'INPUT ERROR
1000 '
1010 '********* CHANGE CONSTANTS *********
1020 '
1028 VTAB(PSTN):FOR SPACE = 1 TO 4 :PRINT"                                      ":
NEXT 'CLEARS ANY PRIOR PROMPTS
1030 VTAB(PSTN):PRINT "ENTER NUMBER OF CONSTANT YOU WOULD":PRINT "LIKE TO CHANGE
 (1 -";NUMB;")  OR C":PRINT"TO CANCEL ==>";
1040 GET ANSWER$:PRINT
1050 IF ANSWER$ = "C" THEN GOTO 820 'DISPLAY CONSTANTS AGAIN
1060 ANSWER =INT(VAL(ANSWER$))
1070 IF ANSWER < 1 OR ANSWER > NUMB THEN:PRINT: PRINT "TYPE ONLY 1 -";NUMB:GOTO
1030 'INPUT ERROR
1078 VTAB(PSTN):FOR SPACE = 1 TO 5:PRINT"
":NEXT 'CLEARS ANY PRIOR PROMPT MESSAGES
1080 VTAB(PSTN):PRINT"ENTER NEW VALUE FOR CONSTANT ";:INPUT "==>",QUANTITY$:PRIN
T
1110 QUANTITY = VAL(QUANTITY$)
1120 IF QUANTITY = 0 THEN PRINT:PRINT "ILLEGAL ENTRY":GOTO 1080
1122 CHANGE = 1
1130 IF ANSWER = 1 THEN TOOL1CENT = QUANTITY
1140 IF ANSWER = 2 THEN TOOL1FACE = QUANTITY
1150 IF ANSWER = 3 THEN TOOL2CENT = QUANTITY
1160 IF ANSWER = 4 THEN TOOL2FACE = QUANTITY
1170 IF ANSWER = 5 THEN CUTWIDTH = QUANTITY
1180 IF ANSWER = 6 THEN RS232 = QUANTITY
1190 IF ANSWER = 7 THEN DISKSLOT = QUANTITY
1200 GOTO 820 'REDISPLAY CONTANTS
1210 '
1220 '******* SAVE CONSTANT CHANGES ******
1230 '
1240 OPEN "O",#1,"LCONST"
1250 WRITE #1,TOOL1CENT,TOOL1FACE,TOOL2CENT,TOOL2FACE,CUTWIDTH,RS232,DISKSLOT
1270 CLOSE
1280 RETURN 'END OF CONSTANT INITIALIZATION
1290 '************************************
1300 '
1310 '**** GET MODE OF OPERATION ****
1320 '
1350 HOME:PRINT SPC(7);"PROGRAM OPERATION CHOICES"
 352 PRINT SPC(15);"FOR LATHE"
 360 PRINT"***************************************"
 370 PRINT:PRINT:NUMB = 1
 372 TAB1 = 5
 380 PRINT NUMB;". MANUAL PART PROGRAMMING":PRINT:MANUAL = NUMB:NUMB = NUMB + 1
 382 PRINT NUMB;". AUTOMATED TEXT GENERATION WITH":PRINT SPC(TAB1);"CONTROL FROM
 APPLE":PRINT:NUMB = NUMB + 1
 390 PRINT NUMB;". AUTOMATED TEXT GENERATION WITH":PRINT SPC(TAB1);"CONTROL FROM
 IBM":PRINT:NUMB = NUMB + 1
 400 PRINT NUMB;". QUIT":PRINT
```

```
050 IF (XSPEED < 1.65 AND XSPEED > 0) OR (ZSPEED < 1.65 AND ZSPEED >0) THEN GOS
B 2790:RETURN 'BELOW MIN SPEED ERROR
060 IF XSPEED > 112 OR ZSPEED > 112 THEN GOSUB 2890:RETURN 'EXCEED MAX SPEED ER
OR
070 DISTANCE= (-1) * X : SPEED=XSPEED
080 GOSUB 2300 'convert to cy512 commands
090 XCY$=CY$
100 DISTANCE=Z : SPEED=ZSPEED
110 GOSUB 2300
120 ZCY$=CY$
130 RETURN
140 '
150 '*** SAVE MOVE IN CY ARRAY ****
160 '
170 'IF G$="7" THEN ABX=0:ABZ=0:CYMOVE$(I%)="$$G7":GOTO 2270
180 PRINT "LINE=";LNE%;" XCY$=";XCY$;" ZCY$=";ZCY$;" M=";M$;" T=";T
190 CYMOVE$(LNE%,1)=XCY$ + " : "  + ZCY$
200 IF T<>0 THEN M$=M$ + "T" + STR$(T) 'ADD IN TOOL NUMBER
210 CYMOVE$(LNE%,2)=M$
220 RETURN
230 '
240 '*** SAVE CY FILE TO DISK ***
250 '
260 FOR LINES% = 1 TO TOTLINES%
270 WRITE #2,CYMOVE$(LINES%,1),CYMOVE$(LINES%,2)
280 NEXT
290 RETURN
300 REM ***************************************
310 REM * ROUTINE TO CONVERT DATA TO CY512 COMMANDS
320 REM ***************************************
330 REM
340 IF DISTANCE = 0 THEN CY$="I,N 0" : RETURN
350 IF DISTANCE < 0 THEN DIRECTION$="-"
360 IF DISTANCE >= 0 THEN DIRECTION$="+"
370 STEPS = CINT(ABS(DISTANCE * 1600))
380 REM *** CALCULATE RATE AND FACTOR FOR CY512 ***
390 SS = SPEED * 26.667
400 IF SS < 43.5 THEN SS = 43.5
410 IF SS > 3000 THEN SS = 3000
420 RATE = CINT(257.938 - (12500! / SS))
430 IF RATE < 1 THEN RATE = 1
440 IF RATE > 253 THEN RATE = 253
450 FACTOR = CINT ((8 * RATE) + (100000! / SS) - 2055.5)
460 IF FACTOR < 1 THEN RATE = RATE + 1:GOTO 2450
470 REM *****************************************
480 REM *  CHECK TO SEE IF R, AND F ARE BEST
490 REM *****************************************
500 FMIN = FACTOR - 1:F = FACTOR:FPLUS = FACTOR + 1
510 FEXP=FMIN:GOSUB 2600
520 ERRMIN = SSERR
530 FEXP=FPLUS:GOSUB 2600
540 ERRPLUS = SSERR
550 FEXP = F:GOSUB 2600
560 IF ERRMIN >= SSERR AND ERRPLUS >= SSERR THEN GOTO 2650
570 IF ERRMIN < SSERR THEN FACTOR = FACTOR - 1:GOTO 2490
580 IF ERRPLUS < SSERR THEN FACTOR = FACTOR + 1:GOTO 2490
```

```
570 IF XX%=1 THEN X=VAL(MID$(SLINE$,XP%+1,CHAR%-XP%-1)):XX%=0:GOTO 1650
580 IF ZZ%=1 THEN Z=VAL(MID$(SLINE$,ZP%+1,CHAR%-ZP%-1)):ZZ%=0:GOTO 1650
590 'IF II%=1 THEN I=VAL(MID$(SLINE$,IP%+1,CHAR%-IP%-1)):II%=0:GOTO 1360
600 'IF JJ%=1 THEN J=VAL(MID$(SLINE$,JP%+1,CHAR%-JP%-1)):JJ%=0:GOTO 1360
610 'IF KK%=1 THEN K=VAL(MID$(SLINE$,KP%+1,CHAR%-KP%-1)):KK%=0:GOTO 1360
620 IF FF%=1 THEN F=VAL(MID$(SLINE$,FP%+1,CHAR%-FP%-1)):FF%=0:GOTO 1650
630 IF MM%=1 THEN M$=MID$(SLINE$,MP%+1,CHAR%-MP%-1):MM%=0
640 IF TT%=1 THEN T=VAL(MID$(SLINE$,TP%+1,CHAR%-TP%-1)):TT%=0:IF T <= 0 OR T> M
XTOOLS% THEN PRINT:PRINT "TOOL NUMBER EXCEEDS MAXIM
M OF";MAXTOOLS%:GOSUB 3190
650 IF C$="N" THEN NP%=CHAR%:NN%=1:GOTO 1770
660 IF C$="G" THEN GP%=CHAR%:GG%=1:GOTO 1770
670 IF C$="X" THEN XP%=CHAR%:XX%=1:GOTO 1770
680 IF C$="Z" THEN ZP%=CHAR%:ZZ%=1:GOTO 1770
690 'IF C$="I" THEN IP%=CHAR%:II%=1:GOTO 1470
700 'IF C$="J" THEN JP%=CHAR%:JJ%=1:GOTO 1470
710 'IF C$="K" THEN KP%=CHAR%:KK%=1:GOTO 1470
720 IF C$="F" THEN FP%=CHAR%:FF%=1:GOTO 1770
730 IF C$="M" THEN MP%=CHAR%:MM%=1:GOTO 1770
740 IF C$="T" THEN TP%=CHAR%:TT%=1:GOTO 1770
750 IF C$="$" THEN CHAR%=LNGTH%:GOTO 1770
760 GOSUB 3060:CHAR% = LNGTH%  'ILLEGAL CHARACTER ERROR
770 RETURN
780 '
790 '*** INTERPOLATE MOVE ***
800 '
810 '****** TAKE CARE OF G CODES ******
820 '
830 IF G$="" GOTO 1940 'NO NEW G COMMANDS
840 IF G$="00" THEN PFLAG%=1:GOTO 1940 'SET FLAG FOR POINT TO POINT POSITIONING
850 IF G$="01" THEN PFLAG%=0:GOTO 1940 'SET FLAG FOR LINEAR INTERPOLATION
860 IF G$="05" THEN ABX=0 : ABZ=0:GOTO 1940 'MAKE PRESENT LOCATION NEW HOME POS
TION
870 IF G$="92" THEN ABX=X:ABZ=Z:X=0:Z=0:GOTO 1940 'PRELOAD ABSOLUTE REGISTERS W
TH THE X AND Z IN PRESENT LINE OF TEXT
880 IF G$="90" THEN ABFLAG%=1:GOTO 1940 'SET FLAG FOR ABSOLUTE DIMENSION INPUT
890 IF G$="91" THEN ABFLAG%=0:GOTO 1940 'SET FLAG FOR INCREMENTAL INPUT
900 IF G$="02" THEN GOSUB 1840:RETURN 'DO ARC INTERPOLATION
910 PRINT:PRINT "G";G$;" IS NOT A LEGAL G FUNCTION CODE":GOSUB 3190 'INTERPRETA
ION ERROR
920 '
930 ' DO G FLAG COMMANDS
940 '
950 IF ABFLAG%=1 THEN X=X - ABX:Z=Z - ABZ 'IF IN ABSOLUTE DIMENSIONINPUT MODE C
NVERTS X AND Z TO INCREMENTAL DIMENSIONES
960 IF PFLAG%=1 THEN XSPEED=VRAPID:ZSPEED=VRAPID:XDIST=X:ZDIST=Z:GOTO 2070 'FOR
POINT TO POINT POSITIONING GO AS RAPID AS POSSIBLE
970 '
980 '*** FIND X AND Z DISTANCES
990 '
000 ABX=ABX + X:ABZ=ABZ + Z 'UPDATE ABSOLUTE REGISTERS
010 IF X=0 AND Z=0 THEN XCY$="R 250,S 1,F 1,N 0,+":ZCY$="R 250,S 1,F 1,N 0,+":R
TURN
020 TLDIST=SQR(X*X+Z*Z)
030 TIME=TLDIST/F
040 XSPEED=ABS(X/TIME) : ZSPEED=ABS(Z/TIME)
```

```
1110 'GET MODE
1120 VTAB(5):PRINT"DO YOU WANT THE PART PROGRAM EXECUTED":PRINT"AFTER IT'S BEEN
INTERPRETED? (Y/N) ===>";:GET ANSWER$
1130 IF ANSWER$="N" THEN MODE%=3:GOTO 1150
1140 IF ANSWER$<>"Y" GOTO 1120
1150 VTAB(5):HTAB(1):PRINT"
       ":PRINT"
                              ":VTAB(5):RETURN
1160 '
1170 ' INPUT FILE SUBROUTINE
1180 '
1190 ON ERROR GOTO 3010
1200 IF OPENED1%=0 THEN OPEN"I",#1,RS274$:OPENED1%=1:ELSE GOTO 1250
1210 P=INSTR(RS274$,".")
1220 CY512$=MID$(RS274$,1,P-1) + ".CYC"
1230 IF OPENED2%=0 THEN OPEN"O",#2,CY512$:OPENED2%=1
1240 ON ERROR GOTO 0
1250 'LOAD A SET OF LINES FROM FILE
1260 TOTLINES%=MAXLINES%:EXMAXLINES%=1 'UNLESS DROPS OUT OF LOOP EARLY, EXCEEDS
MAX NUMBER OF LINES INTERPRETED FLAG IS SET
1270 FOR LINES% = 1 TO MAXLINES%
1280 IF EOF(1) THEN GOTO 1320
1290 INPUT #1,SLINE$(LINES%)
1300 IF SLINE$(LINES%) = "$" THEN TOTLINES% = LINES% - 1 :EXMAXLINES%=0:LINES%=M
AXLINES%
1310 NEXT
1320 RETURN
1330 REM
1340 REM ***** SEPARATE PARAMETERS AND CHECK FOR ERRORS *****
1350 REM
1360 'INITIALZE ALPHA SEARCH VARIABLES
1370 X=0:Z=0:G$="":M$="":T=0
1380 LNGTH%=LEN(SLINE$):IF LNGTH% > MAXCHAR% THEN PRINT "LENGTH OF INPUT LINE EX
CEEDS MAXIMUM ALLOWABLE OF";MAXCHAR%:GOSUB 3190:RETU
RN 'INTERPRET ERROR
1390 FOR CHAR% = 1 TO LNGTH%
1400 C$=MID$(SLINE$,CHAR%,1)
1410 GOOD%=0
1420 IF C$ >= "A" AND C$ <= "Z"  THEN GOSUB 1540:GOTO 1480 'CHECK FOR ALPHA COMM
AND
1430 IF C$="$" THEN GOSUB 1540:CHAR%=LNGTH%:GOTO 1480
1440 IF C$="+" OR C$="-"  OR C$="." THEN GOOD%=1
1450 IF C$=" " THEN SLINE$=LEFT$(SLINE$,CHAR%-1) + MID$(SLINE$,CHAR%+1):GOTO 140
0 'DELETES SPACES AND STARTS AGAIN FOR THIS CHARACTE
R
1460 IF C$>= "0" AND C$<= "9" THEN GOOD%=1
470 IF GOOD%=0 THEN GOSUB 3060:CHAR% = LNGTH% 'ILLEGAL CHARACTER ERROR
480 NEXT
490 PRINT"SLINE=";SLINE$
500 PRINT"N=";NLINE%;" G=";G$;" X=";X;" Z=";Z;" M=";M$;" T=";T
510 RETURN
520 REM
530 REM ****** CHECK, SORT, AND STORE NEW PARAMETER *******
540 REM
550 IF NN%=1 THEN NLINE%=VAL(MID$(SLINE$,NP%+1,CHAR%-NP%-1)):NN%=0:GOTO 1650
560 IF GG%=1 THEN G$=MID$(SLINE$,GP%-1,CHAR%-GP%-1):GG%=0:GOTO 1650
```

```
650     IF M$ >= " 0" AND M$ <= " 3" GOTO 700 'STOP PROGRAM EXECUTION COMMAND
670     IF M$=" 6" THEN GOSUB 3490 'CHANGE TOOL COMMAND
680 NEXT
682 '
690 IF EXMAXLINES%=1 THEN GOTO 580 'IF FILE EXCEEDEDS MAXLINES HANDLED IN ONE SE
T DO AGAIN
692 '
700 CLOSE:OPENED1%=0:OPENED2%=0
702 '
710 IF CALLER1$ <> "" THEN GOTO 740
720 GOSUB 3760 'DO PART AGAIN?
730 IF CSTOP=0 GOTO 540
732 '
740 'EXIT
742 '
760 DONE$=CHR$(1) 'MUX POLLING ATTENTION GETTER
780 IF CALLER1$ <> "" THEN Q$=USR7(DONE$):CHAIN CALLER1$
790 END
800 '
802 '************************************
804 '
810 ' *** INITIALIZE VARIABLES AND COMMUNICATION SUSBROUTINES
820 '
830 MAXLINES%=100
840 MAXCHAR%=80
850 BELL$=CHR$(7)
860 DIM SLINE$(MAXLINES%)
870 DIM CYMOVE$(MAXLINES%,2) 'CY512 COMMANDS,M COMMANDS
880 CY%=1:MC%=2 'POSITION IN ARRAY OF CY COMMANDS AND M COMMANDS
890 DIM CY$(2) 'HOLDS SEPARATED FOR X AND Z AXIS
900 XP%=1:ZP%=2 'POSITIONS OF X AND Z PARAMETERS
910 YCY$="R 250,S 1,F 1,N 0,+"
920 VRAPID=100 'VERY FASTEST FEEDRATE X OR Z AXIS CAN TRAVEL
930 MAXTOOLS%=9 'HIGHEST TOOL NUMBER ALLOWED
940 'COMMUNICATION SUBROUTINES
950 'CALLER$="LATHE.INT":CLINE=700:PRGM$="XXXX":SLINE=999:HFILE$="XXXX" 'SET PAR
AMETERS TO RETURN TO THIS PROGRAM
960 'CHAIN "LOADASM",,ALL 'LOADS ALL ASSEMBLY LANGUAGE SUBROUTINES
970 HOME:PRINT "LATHE CNC EXECUTOR                                       - BYU M
INI LAB -""
980 PRINT:PRINT"----------------------------------------------------------------
---------------":PRINT:PRINT:PRINT
990 RETURN
1000 '
1010  ' GET NAME OF FILE TO INTERPRET
1020 '
1030 IF CALLER1$ <> ""  THEN X=INSTR(RS274$,"."):CY512$=LEFT$(RS274$,X-1)+".CYC"
:RETURN 'PROGRAM BEING CHAINED TO
1040 VTAB(5):INPUT "PROCESS WHAT CNC FILE ";RS274$
1050 TEST$=RIGHT$ ( RS274$,4 )
1060 IF TEST$=".CYC" THEN MODE%=2:CY512$=RS274$:RETURN 'EXECUTE PREINTERPRETED F
ILE
1070 IF LEFT$( TEST$,1 ) = "." THEN GOTO 1090
1080 RS274$ = RS274$ + ".CNC"
1090 IF MID$(RS274$,2,1) = ":" THEN LLL = 14 ELSE LLL = 12
1100 IF LEN(RS274$)>LLL THEN PRINT:PRINT "FILENAME TOO LONG!":PRINT:GOTO 1040
```

```
250 REM **************************
255 REM *    POKE BYTES S/R      *
260 REM **************************
265 FOR I = 1 TO BYTES
270 LOCATION=ADDRESS + (I - 1)
275 CODE$="&H" + MID$(HLINE$,(8 + (I * 2)),2)
280 CODE=VAL(CODE$)
285 POKE LOCATION,CODE
290 NEXT I
295 RETURN
300 DEF USR1=&HC409
310 DEF USR2=&HC416
320 DEF USR3=&HC423
324 '**********************************
330 '
340 ' *** MAIN BODY OF PROGRAM ***
350 '
354 '***********************************
360 'INTERPRET FILE
370 '
380 GOSUB 800 'INITIALIZE VARIABLES AND COMMUNICATION SUBROUTINES
384 '
390 GOSUB 1020 'GET FILE NAME
394 '
400 IF MODE% = 2 THEN LFILE% = 1:GOTO 540 'EXECUTE PREINTERPRETED FILE
402 '
410 GOSUB 1180 'INPUT A SET OF LINES
420 PRINT"INTERPRETING FILE";
422 '
430 FOR LNE% = 1 TO TOTLINES%
440    SLINE$=SLINE$(LNE%)
450    GOSUB 1350 'SEPARATE PARAMETERS
460    GOSUB 1790 'INTERPOLATE MOVE
470    GOSUB 2150 'SAVE MOVE TO CY ARRAY
480 PRINT".";:NEXT 'INTERPRET NEXT LINE OF RS2374 FILE
484 '
490 GOSUB 2250 'SAVE CY ARRAY TO DISK
494 '
500 IF EXMAXLINES%=1 GOTO 410 'FILE EXCEEDED MAXIMUM LINES HANDLES IN ONE SET SO
 LOAD IN NEXT SET
510 WRITE #2,"$$$$"," ":CLOSE:OPENED1%=0:OPENED2%=0 'CLOSE ALL FILES, LAST ENTRY
 IN FILE IS EOF MARKER FOR CY512 FILE
520 IF INERROR%=1 THEN GOTO 740 'IF INTERPRETATION ERROR OCCURED THEN EXIT
530 '
540 '*** EXECUTE FILE ***
550 '
560 IF MODE%=3 THEN GOTO 740 'EXIT BECAUSE ISN'T TO BE EXECUTED
562 '
570 PRINT:PRINT"EXECUTING FILE";:STRTLINE%=1
580 IF LFILE%=1 THEN PRINT"LOADING IN FILE":GOSUB 3270 'FILE EXCEEDED MAXIMUM LI
NES HANDLED IN ONE SET SO LOAD FILE FORM DISK
582 '
590 FOR LNE%=1 TO TOTLINES%
610    GOSUB 3370 'EXECUTE X,Z MOVE
630    IF CYMOVE$(LNE%,MC%) = "" THEN GOTO 680 ' NO M COMMAND
640    M$=STR$(VAL(CYMOVE$(LNE%,MC%))) 'FIND M COMMAND VALUE
```

```
10 REM ******************************************************
20 REM *
30 REM *      LATHE.INT         BY GREGORY J. PETO
40 REM *                           - BYU CAM LAB -
50 REM *  RS274 - CY512 TRANSLATOR   MAY, 1984
60 REM *
62 REM * ADAPTED FROM LINTERP.BAS AND CYEXEC.BAS BY JUSTIN D. REDD
64 REM *
70 REM *  THIS PROGRAM READS RS274 STANDARD NUMERICAL CONTROL.
74 REM *     IHE RS274 FILE MUST HAVE THE EXTENTION .CNC.
80 REM *  CODES FROM A TEXT FILE AND TRANSLATES THEM TO
90 REM *    COMMANDS FOR THE CY512 STEPPER MOTER CONTROLLER
94 REM *    AND WILL THEN EXECUTE THE FILE IF THAT OPTION IS CHOSEN.
100 REM*  THE RESULTING CY512 COMMANDS ARE STORED IN A TEXT
110 REM*    FILE OF THE SAME NAME WITH THE EXTENSION OF .CYC
114 REM*  MIN AXIS SPEED IS 1.65 IN./MIN.
116 REM*  MAX AXIS SPEED IS 112 IN./MIN.
118 REM*  *** CHAINING TO THIS PROGRAM ***
120 REM*    CALLER PROGRAM SHOULD PUT ITS OWN NAME IN CALLER1$ AND IT'S
122 REM*      RETURN LINE NUMBER IN SLINE1.
124 REM*    THE NAME OF THE FILE TO BE INTERPRETED SHOULD BE PUT IN RS274$
126 REM*    IF EXECUTING PREINTERPRETED FILE THEN PUT IT'S NAME IN CY512$
128 REM*       AND SET MODE% = 2.
130 REM******************************************************
132 '
134 ' CHECK FOR CYDRIVER.HEX IN MEMORY
136 '
137 HOME
138 PRINT:INVERSE:PRINT "CHECKING FOR CYDRIVER.HEX";:NORMAL:PRINT
140 MESS$=""
142 FOR CHAR = 0 TO 6
144 LOCATION = &HC4F1 + CHAR
146 CHAR$=CHR$(PEEK(LOCATION))
148 MESS$=MESS$ + CHAR$:CHAR$= ""
150 NEXT CHAR
152 IF LEFT$(MESS$,5) <> "VALID" THEN GOTO 158
154 X$=MID$(MESS$,6,1)
156 IF X$="1" THEN GOTO 300
158 PRINT:INVERSE:PRINT "LOADING CYDRIVER.HEX AT C400H";:NORMAL:PRINT
160 HFILE$="CYDRIVER.HEX"
170 OPEN"I",#1,HFILE$
175 GOSUB 195
180 GOSUB 250
185 GOTO 175
190 REM
195 REM **************************
200 REM *    READ LINE S/R       *
205 REM **************************
210 REM
215 INPUT #1,HLINE$
220 HBYTES$="&H" + MID$(HLINE$,2,2)
225 HADDRESS$="&H" + MID$(HLINE$,4,4)
230 BYTES=VAL(HBYTES$):ADDRESS=VAL(HADDRESS$)
235 IF BYTES=0 AND ADDRESS=0 THEN HOME:CLOSE:PRINT "PROGRAM LOADED"
240 RETURN
245 REM
```

```
4990 ZNUL=0:Z=STOCKLEN - TOOL2FACE -(OFFSET(1) + CUTREF / 2 + FUDGE) + CUTWIDTH
5000 Z1=Z '1ST MOVE
5004 XNUL=1
5010 FEEDRATE=SHORT
5020 GOSUB 2820 'PUT IN MOVE ARRAY
5030 'MOVE TOWARD CENTER
5040 XNUL=0:X=STOCKDIAM / 2 + CLRNC
5050 ZNUL=1
5060 FEEDRATE=CUTOFFSPEED
5070 GOSUB 2820
5080 'MOVE AWAY FROM CENTER
5090 X= -X
5100 FEEDRATE=RAPID
5110 GOSUB 2820
5120 'RETURN TO START POSITION
5130 X= -X1
5132 ZNUL=1
5134 FEEDRATE=SHORT
5136 GOSUB 2820
5140 ZNUL=0:Z= -Z1
5144 XNUL=1
5146 FEEDRATE=RAPID
5150 GOSUB 2820
5160 COMMAND=1:X$=STP$
5170 GOSUB 2820
5180 RETURN
5190 '******************************
5200 '
5210 '***** SAVE DATA TO DISK *****
5220 '
5230 HOME
5240 PRINT:PRINT"WRITING TO DISK";
5250 FILENAME$="L" + PRTNUMB$ + ".CNC"
5260 OPEN "O",#1,FILENAME$
5270 'WRITE #1,STOCKLEN,FEEDREF,CUTREF,STOCKDIAM 'FILE HEADER
5280 'THIS LOOP WRITES OUT MOVES
5290 FOR NUMB% = 1 TO COUNT-1 'COUNT HOLD VALUE OF NEXT MOVE
5300 PRINT #1,"N";NUMB%;MOVE$(NUMB%)
5302 PRINT".";
5310 NEXT
5312 PRINT #1,"$"
5314 CLOSE
5320 COUNT = 1 'REINITIALIZE NUMBER OF MOVES
5330 RETURN
5340 '*********************************
```

```
4460 'MOVE TOOL AWAY FROM PART
4470 XNUL=0:X= -CLRNC
4480 Z=CLRNC
4490 FEEDRATE=SHORT
4500 GOSUB 2820
4510 'MOVE BACK TO RIGHT END
4520 XNUL=1
4530 Z=CUTL
4540 FEEDRATE=RAPID
4550 GOSUB 2820
4560 NEXT
4570 RETURN
4580 '***************************
4600 '
4610 '****** DO FINISH CUT ******
4620 '
4630 'MOVE RIGHT TO POSITION TO DO FINISH FACE OF RIGHT END
4640 XNUL=1
4650 ZNUL=0:Z= -(CUTREF / 2 + CLRNC)
4660 FEEDRATE=SHORT
4670 GOSUB 2820 'PUT IN MOVE ARRAY
4680 'MOVE TOWARD CENTER
4690 XNUL=0:X=DMENSION(NUMBDIAM,WDTH) / 2 + CLRNC 'NUMBDIAM IS LAST DIAM - THE D
IAMETER OF THE FACE
4700 ZNUL=1
4710 FEEDRATE=FEEDREF
4720 GOSUB 2820
4730 'MOVE AWAY FROM CENTER
4740 X= -X + CLRNC 'MOVE OUT SAME DISTANCE MOVED IN AND THEN BACK IN A CLEARANCE
4750 GOSUB 2820
4760 'DO A FINISH PASS FOR EACH DIAMETER
4770 FOR DIAMNUMB = NUMBDIAM TO 1 STEP -1
4780 'MOVE LEFT LENGTH OF DIAMETER
4790 XNUL=1
4800 ZNUL=0:Z= -DMENSION(DIAMNUMB,LENGTH)
4810 GOSUB 2820
4820 'MOVE AWAY FROM CENTER TO MAKE NEXT LEFT MOVE
4830 IF DIAMNUMB = 1 THEN GOTO 4870 'ALREADY FINISHED
4840 XNUL=0:X= -((DMENSION(DIAMNUMB-1,WDTH) - DMENSION(DIAMNUMB,WDTH)) / 2)
4850 ZNUL=1
4860 GOSUB 2820
4870 NEXT
4880 'STOP FOR TOOL CHANGE. REINITIALIZES POSITION
4890 COMMAND=1:X$=TOOL$+"T2" 'COMMAND TO INSERT TOOL NUMBER 2 - THE CUTOFF TOOL
4900 GOSUB 2820
4910 RETURN
4920 '******************************
4930 '
4940 '********* DO CUTOFF *********
4950 '
4960 'MOVE TO POSITION TO START CUTOFF
4970 XNUL=0:X= -(STOCKDIAM + CLRNC) + TOOL2CENT
4980 X1=X '1ST MOVE
4984 ZNUL=1
4985 FEEDRATE=SHORT
4986 GOSUB 2820 'PUT IN MOVE ARRAY
```

```
3930 ZNUL=0:Z=STOCKLEN - TOOL1FACE - CUTREF 'MOVES HORIZONTALLY. SETUP TO REFINI
SH FACE OF END
3940 FEEDINIT=1:FEEDRATE=RAPID
3950 GOSUB 2820 'PUT IN ARRAY
3960 'MOVW TOWARD CENTER TO TOUCHUP FACE OF END
3970 X=STOCKDIAM / 2 + CLRNC
3980 ZNUL=1
3990 FEEDRATE=FEEDREF
4000 GOSUB 2820
4010 'MOVE AWAY FROM FACE
4020 XNUL=1
4030 ZNUL=0:Z=CLRNC
4040 FEEDRATE=SHORT
4050 GOSUB 2820
4060 'MOVE AWWAY FROM CENTER
4070 XNUL=0:X= -X
4080 ZNUL=1
4090 GOSUB 2820
4100 RETURN
4110 '*******************************
4120 '
4130 '****** DO ROUGH CUT ******
4140 '
4150 FOR DIAMNUMB% = 1 TO NUMBDIAM
4160 'DOES A ROUGH CUTTING PROCEDURE FOR EACH DIAMETER
4170 GOSUB 4250 'FIND NUMBER OF PASSES AND DEPTH OF EACH
4180 GOSUB 4330 'DO ROUGH PASSES
4190 NEXT
4210 RETURN
4220 '****************************
4230 '
4240 '* FIND ROUGH CUT DEPTH & NUMBER *
4250 '
4252 IF DIAMNUMB% = 1 THEN TOTCUT=(STOCKDIAM-DMENSION(1,WDTH))/2:GOTO 4270 'FIRS
T CUT IS FROM STOCK FACE DOWN TO DIAM 1
4260 TOTCUT=(DMENSION(DIAMNUMB% - 1,WDTH) - DMENSION(DIAMNUMB%,WDTH)) / 2 'FIND
TOTAL WIDTH TO BE CUT OUT
4270 NUMBCUTS%=CINT(TOTCUT / CUTREF) 'FINDS NUMBER OF PASSES REQUIRED
4280 CUTDEPTH=TOTCUT / NUMBCUTS% 'FINDS EXACT CUT DEPTH OF EACH PASS
4290 RETURN
4300 '******************************
4310 '
4320 '****** DO ROUGH PASSES ******
4330 '
4340 CUTL=OFFSET(DIAMNUMB%) 'FINDS LENGTH OF EACH PASS
4350 FOR CUTN% = 1 TO NUMBCUTS%
4360 'MOVE TOWARD CENTER FOR PASS
4370 XNUL=0:X=CUTDEPTH + CLRNC
4380 ZNUL=1
4390 FEEDRATE=SHORT
4400 GOSUB 2820 'PUT IN MOVE ARRAY
4410 'DO PASS
4420 ZNUL=0:Z= -(CUTL + CLRNC)
4430 XNUL=1
4440 FEEDRATE=FEEDREF 'RATE CHOSEN BY PROGRAMMER
4450 GOSUB 2820
```

```
3331 READY$="PLOADED"+CHR$(13)
3332 Q$=USR7(READY$) 'SEND READY SIGNAL TO IBM
3334 Q$=USR8(IBM$):PRINT"SENT PLOADED.  IBM SENT ==>";IBM$
3335 BAD$="BAD"+CHR$(13)
3336 X=0:X=INSTR(IBM$,"OK"):IF X=0 THEN PRINT:PRINT"ERROR RECIEVING FROM IBM":Q$
=USR7(BAD$):GOTO 3332
3338 READY$="GOOD"+CHR$(13):Q$=USR7(READY$)
3340 'Q$=USR8(PRTNAME$) 'PART NAME
3342 'PRINT"PART NAME RECEIVED ==>";PRTNAME$
3344 Q$=USR8(PRTNUMB$) 'PART NUMBER
3346 PRINT"PART NUMBER RECEIVED ==>";PRTNUMB$
3350 Q$=USR8(PRTFMLY$) 'PART FAMILY
3360 Q$=USR8(ANSWER$):NUMBDIAM = VAL(ANSWER$) 'NUMBER OF DIAMETERS
3364 PRINT"NUMBER OF DIAMETERS ===>";NUMBDIAM
3370 Q$=USR8(ANSWER$):FEEDREF = VAL(ANSWER$) 'FEEDRATE
3374 PRINT"FEED RATE ===>";FEEDREF
3380 Q$=USR8(ANSWER$):CUTREF = VAL(ANSWER$) 'CUT DEPTH
3384 PRINT"CUT DEPTH ===>";CUTREF
3390 Q$=USR8(ANSWER$):STOCKDIAM = VAL(ANSWER$) 'STOCK DIAMETER
3394 PRINT"STOCK DIAMETER ===>";STOCKDIAM
3400 Q$=USR8(ANSWER$):STOCKLEN = VAL(ANSWER$) 'STOCK LENGTH
3401 PRINT"STOCK LENGTH ===>";STOCKLEN
3402 FOR COUNTER%=1 TO NUMBDIAM
3404 Q$=USR8(ANSWER$):DMENSION(COUNTER%,LENGTH)=VAL(ANSWER$)
3405 PRINT"LENGTH DIAM.";COUNTER%;" ===>";DMENSION(COUNTER%,LENGTH)
3406 Q$=USR8(ANSWER$):DMENSION(COUNTER%,WDTH)=VAL(ANSWER$)
3407 PRINT"WIDTH DIAM.";COUNTER%;"  ===>";DMENSION(COUNTER%,WDTH)
3408 NEXT
3409 INPUT "HOLDING",HOLD$
3410 RETURN
3720 RETURN
3740 '
3750 '**** INITIAL LATHE CALC'S
3760 '
3770 HOME:PRINT"CALCULATING LATHE MOVES";
3772 COMMAND=1:X$=TOOL$+"T1":GOSUB 2820 'IST LINE IS COMMAND TO PUT IN TOOL #1
3780 'CALCULATE DISTANCE FROM LEFT REFERENCE FOR EACH DIAMETER
3790 FOR DIAMNUMB = 1 TO NUMBDIAM
3792 OFFSET(DIAMNUMB)=DMENSION(DIAMNUMB,WDTH)
3800 FOR OTHERDIAM = DIAMNUMB + 1 TO NUMBDIAM
3810 OFFSET(DIAMNUMB) = OFFSET(DIAMNUMB) +DMENSION(OTHERDIAM,LENGTH)
3820 NEXT:NEXT
3830 OFFSET(1) = OFFSET(1) + WIDTHCUT 'ADDS WIDTH OF CUT OFF TOOL TO 1ST DIAMETE
R
3840 'ALLOW FOR FINISH CUT
3850 FOR DIAMNUMB = 1 TO NUMBDIAM
3852 DMENSION(DIAMNUMB,WDTH) = DMENSION(DIAMNUMB,WDTH) + CUTREF/2 'ADDS WIDTH SO
 THAT AFTER ROUGH CUT WILL BE SLIGHTLY OVER SIZED
3854 NEXT
3860 RETURN
3870 '********************************
3880 '
3890 '**** DO FREE END FACE ****
3900 '
3910 'MOVE TO START POSITION
3920 XNUL=0:X=TOOL1CENT - STOCKDIAM / 2 - CLRNC 'MOVES TOOL BACK SO CAN MOVE
```

```
2860 OUTLINE$=""
2870 IF COMMAND=1 THEN OUTLINE$=X$ + "$":COMMAND=0:GOTO 2912 'STORE COMMAND IN A
RRAY
2880 IF XNUL = 0 THEN OUTLINE$="X" + STR$(X):TOTX = TOTX + X
2890 IF ZNUL = 0 THEN OUTLINE$=OUTLINE$ + "Z" + STR$(Z):TOTZ=TOTZ + Z
2900 IF FEEDINIT = 0 THEN INVERSE:PRINT"YOU'LL NEED TO GIVE FEEDRATE AN":PRINT"I
NITIAL VALUE OR MOVE CANNOT BE DONE.":NORMAL:PRINT:P
RINT"HIT ANY KEY TO CONTINUE";:GET HOLD$:RETURN
2910 OUTLINE$=OUTLINE$ + "F" + STR$(FEEDRATE) +"$"
2912 'STORE IT
2920 MOVE$(COUNT)=OUTLINE$
2930 COUNT=COUNT + 1
2940 PRINT"."; 'LETS OPERATOR KNOW IT IS RUNNING
2950 RETURN
2960 '***************************************
3000 '
3010 '* GET PART DESCRIPTION-APPLE CONTROL
3020 '
3030 GOSUB 1990 'GET GENERAL DESCRIPTION
3040 GOSUB 3090 'GET DIMENSIONS OF PART
3050 RETURN
3060 '*******************************
3070 '
3080 '* GET DIMENSIONS APPLE CONTROL *
3090 '
3100 TOTX=0:TOTZ=0
3120 FOR DIAMNUMB = 1 TO NUMBDIAM
3122 VTAB(PSTN):FOR SPACE = 1 TO 14 :PRINT CLR$:NEXT 'CLEAR SCREEN
3130 VTAB(PSTN):PRINT"ENTER WIDTH OF DIAMETER #";DIAMNUMB;
3140 INPUT" ==>",ANSWER$
3150 DMENSION(DIAMNUMB,WDTH)=VAL(ANSWER$)
3160 IF DMENSION(DIAMNUMB,WDTH) <= 0 OR DMENSION(DIAMNUMB,WDTH) > STOCKDIAM THEN
 PRINT:PRINT"MAXIMUM TOTAL WIDTH IS";STOCKDIAM:GOTO
3130
3170 IF DIAMNUMB>1 THEN IF DMENSION(DIAMNUMB,WDTH)+CUTREF>=DMENSION(DIAMNUMB-1,W
DTH) THEN PRINT:PRINT"EACH SUCCESIVE DIAMETER WIDTH
MUST BE":PRINT"LESS THAN THE LAST BY";CUTREF:PRINT:PRINT"DIAMETER #";DIAMNUMB-1;
" WIDTH IS";DMENSION(DIAMNUMB-1,WDTH):GOTO 3130
3180 TOTX = TOTX + DMENSION(DIAMNUMB,WDTH)
3188 TOTLEN=STOCKLEN - CLRNC - CUTWIDTH 'MAX TOTAL LENGTH IS STOCK LENGTH MINUS
A CLEARANCE AND CUTOFF TOOL WIDTH
3190 VTAB(PSTN):FOR SPACE = 1 TO 8:PRINT CLR$:NEXT
3200 VTAB(PSTN):PRINT"ENTER LENGTH OF DIAMETER #";DIAMNUMB;:INPUT" ==>",ANSWER$
3210 DMENSION(DIAMNUMB,LENGTH) = VAL(ANSWER$)
3220 IF DMENSION(DIAMNUMB,LENGTH) < MINLEN OR DMENSION(DIAMNUMB,LENGTH) + TOTZ >
 TOTLEN THEN PRINT:PRINT"MAXIMUM TOTAL LENGTH IS";TO
TLEN;" AND ANY ":PRINT"ONE DIAMETER MUST BE GREATER THAN";MINLEN:PRINT"CURRENT T
OTAL LENGTH IS";TOTZ:GOTO 3200
3230 TOTZ=TOTZ + DMENSION(DIAMNUMB,LENGTH)
3240 NEXT 'LOOP BACK FOR NEXT DIAMETER
3250 RETURN
3260 '******************************
3300 '
3310 '*** GET PART DESCRIPTION - IBM CONTROL ***
3320 '
3330 ' LOAD IN PART DESCRIPTION
```

```
2452 TOTX=TOOL1CENT:TOTZ=TOOL1FACE 'INITIALIZE ACCUMULATED X AND Z VALUES FOR CU
TTING TOOL
2460 HOME:PRINT"TYPE IN DESIRED NEW VALUE AND THEN":PRINT"TYPE -RETURN-.":PRINT
2470 PRINT"X MOVES CUTTER TOWARD CENTER IF POSITIVE"
2480 PRINT"Z MOVES CUTTER ALONG CENTER LINE TO":PRINT"RIGHT IF POSITIVE"
2490 PRINT"X AND Z ARE BOTH RELATIVE, FEEDRATE":PRINT"IS ABLSOLUTE."
2500 PRINT:PRINT"TYPE NOTHING BUT -RETURN- AND THAT":PRINT"PARAMETER STAYS THE S
AME"
2510 PRINT:PRINT"TYPE S FOR STOP OR T FOR TOOL CHANGE"
2520 PRINT"OR E FOR EXIT IN X VALUE."
2532 PRINT"**************************************"
2540 PSTN=17 'POSITION TO START INPUT LINE
2550 'GET NEXT POINT
2560 XNUL=0:ZNUL=0
2572 CLR$="                                      "
2574 VTAB(PSTN):FOR SPACE=1 TO 4:PRINT CLR$:NEXT 'CLEAR SCREEN
2580 VTAB(PSTN):INPUT"ENTER NEXT X VALUE ==>",ANSWER$
2590 IF ANSWER$="" THEN XNUL=1:GOTO 2652 'JUMP TO Z
2600 IF ANSWER$="S" THEN COMMAND=1:X$=STP$:GOSUB 2830:TOTX=TOOL1CENT:TOTZ=TOOL1F
ACE:GOTO 2550
2610 IF ANSWER$="T" THEN COMMAND=1:X$=TOOL$:GOSUB 2830:TOTX=TOOL1CENT:TOTZ=TOOL1
FACE:GOTO 2550
2620 IF ANSWER$="E" THEN RETURN 'EXIT. PROGRAMMING FINISHED
2630 X=VAL(ANSWER$)
2640 IF X+TOTX < MAXX THEN PRINT:PRINT"TOTAL X CANNOT BE LESS THEN";MAXX;"
   ":PRINT CLR$:GOTO 2580
2641 IF X+TOTX > -MAXX THEN PRINT:PRINT"TOTAL X CANNOT BE GREATER THAN";-MAXX"
     ":PRINT CLR$:GOTO 2580
2642 IF X = 0 THEN PRINT:PRINT"TYPE NOTHING BUT -ENTER- IF X":PRINT"DOESN'T CHAN
GE         ":GOTO 2580
2650 VTAB(PSTN):FOR SPACE=1 TO 4:PRINT CLR$:NEXT
2652 'GET Z VALUE
2670 VTAB(PSTN):INPUT"ENTER NEXT Z VALUE ==>",ANSWER$
2680 IF ANSWER$="" THEN ZNUL=1:GOTO 2702 'JUMP TO FEEDRATE
2690 Z=VAL(ANSWER$)
2698 IF Z = 0 THEN PRINT:PRINT"TYPE NOTHING BUT -RETURN- IF Z         ":PRINT"DO
ESN'T CHANGE":GOTO 2670
2700 IF Z+TOTZ < 0 OR Z+TOTZ > MAXZ THEN PRINT:PRINT"TOTAL Z CANNOT BE LESS THAN
 0 OR":PRINT"GREATER THAN";MAXZ:GOTO 2670
2702 VTAB(PSTN):FOR SPACE=1 TO 4:PRINT CLR$:NEXT
2710 'GET FEEDRATE
2720 VTAB(PSTN):INPUT"ENTER FEEDRATE ==>",ANSWER$
2730 IF ANSWER$="" THEN :GOTO 2770 'JUMP TO PUT IN ARRAY
2740 FEEDRATE=VAL(ANSWER$)
2750 IF FEEDRATE < MINFEED THEN PRINT:PRINT"FEEDRATE CANNOT BE LESS THAN";MINFEE
D:GOTO 2720
2760 FEEDINIT = 1 'FEEDRATE HAS BEEN INITIALIZED
2770 GOSUB 2830 'PUT MOVE IN ARRAY
2780 GOTO 2550 'GET NEXT MOVE
2790 '**************************************
2800 '
2810 '********** PUT IN ARRAY ***********
2820 '
2830 'X AND Z ARE PASSED AS NUMBERS XNULL AND ZNULL ARE USED TO INDICATE THERE A
RE NO CHANGES IN THOSE PARAMETERS
2850 IF XNUL=1 AND YNUL=1 THEN RETURN 'NO ENTRIES MADE
```

```
2100 IF ANSWER$ <> "N" THEN PRINT:PRINT"TYPE ONLY Y OR N":GOTO 2080 'INPUT ERROR
2110 VTAB(PSTN):FOR SPACE = 1 TO 10:PRINT CLR$:NEXT 'CLEARS ALL BUT TOP OF SCREE
N
2120 GOOD = 0
2122 VTAB(PSTN):INPUT"ENTER PART FAMILY ==>",PRTFMLY$
2130 IF PRTFMLY$ = "A00" THEN NUMBDIAM = 1:GOOD=1
2140 IF PRTFMLY$ = "A10" THEN NUMBDIAM = 2:GOOD=1
2150 IF PRTFMLY$ = "A20" THEN PRINT:PRINT"MAXIMUM NUMBER OF DIAMETERS IS ";DIAMA
X:PRINT:INPUT"ENTER NUMBER OF DIAMETERS ==>",ANSWER$
:NUMBDIAM = INT(VAL(ANSWER$)):IF NUMBDIAM >= 2 AND NUMBDIAM <= DIAMAX THEN GOOD
= 1
2170 IF GOOD = 0 THEN PRINT:PRINT"FAMILY NOT RECOGNIZED":GOTO 2120 'INPUT ERROR
2180 VTAB(PSTN):FOR SPACE = 1 TO 8:PRINT CLR$:NEXT
2190 VTAB(PSTN):PRINT"TYPICAL FEEDRATES FOR MINI-LATHE ARE":PRINT"3 TO 10 IN./MI
N. 4-5 IS MAX FOR ALUMINUM."
2200 VTAB(PSTN + 5):INPUT"ENTER FEEDRATE ==>",ANSWER$
2210 FEEDREF=INT(VAL(ANSWER$))
2220 IF FEEDREF < MINFEED OR FEEDREF > MAXFEED THEN PRINT:PRINT"FEEDRATE CANNOT
BE LESS THAN";MINFEED;"OR":PRINT"GREATER THAN";MAXFE
ED:GOTO 2200 'INPUT ERROR
2230 VTAB(PSTN):FOR SPACE = 1 TO 9:PRINT CLR$:NEXT
2240 VTAB(PSTN):PRINT"TYPICAL CUT DEPTH PER PASS IS .01 IN.":PRINT"FOR MINI-LATH
E."
2250 VTAB(PSTN + 5):INPUT"ENTER DEPTH OF CUT IN INCHES ==>",ANSWER$
2260 CUTREF=VAL(ANSWER$)
2270 IF CUTREF <= 0 OR CUTREF > MAXCUT THEN PRINT:PRINT"CUT DEPTH CANNOT BE GREA
TER THAN";MAXCUT:GOTO 2250
2280 VTAB(PSTN):FOR SPACE = 1 TO 8:PRINT CLR$:NEXT
2290 VTAB(PSTN):PRINT"DEMO STOCK DIAMETER IS .5 INCHES"
2300 VTAB(PSTN + 5):INPUT"ENTER STOCK DIAMETER ==>",ANSWER$
2310 STOCKDIAM = VAL(ANSWER$)
2320 IF STOCKDIAM <= 0 OR STOCKDIAM > MAXDIAM THEN PRINT:PRINT"DIAMETER CANNOT B
E GREATER THAN";MAXDIAM:GOTO 2300
2322 VTAB(PSTN):FOR SPACE = 1 TO 8:PRINT CLR$:NEXT
2324 VTAB(PSTN):PRINT"TYPICAL STOCK LENGTH IS 3 INCHES":PRINT"IT MUST BE LONGER
THAN PART":PRINT"PLUS TOOLWIDTHS"
2326 VTAB(PSTN + 5):INPUT"ENTER STOCK LENGTH ==>",ANSWER$
2327 STOCKLEN = VAL(ANSWER$)
2328 IF STOCKLEN <= 0 OR STOCKLEN > MAXLEN THEN PRINT:PRINT"CANNOT BE LONGER THE
N";MAXLEN:GOTO 2326
2330 VTAB(PSTN):FOR SPACE = 1 TO 8:PRINT CLR$:NEXT
2340 VTAB(PSTN):PRINT"PART FAMILY IS ";PRTFMLY$;" (WITH";NUMBDIAM;"DIAMETERS)"
2350 PRINT:PRINT"REFERENCE FEERATE IS";FEEDREF
2360 PRINT:PRINT"REFERENCE CUTDEPTH IS";CUTREF
2370 PRINT:PRINT"STOCK DIAMETER IS";STOCKDIAM
2380 PRINT:PRINT"STOCK LENGTH IS";STOCKLEN
2390 VTAB(PSTN + 11):PRINT"DO YOU WANT TO CHANGE ANY OF":PRINT"ABOVE (Y/N) ";:GE
T ANSWER$:PRINT
2400 IF ANSWER$ = "Y" THEN VTAB(PSTN):FOR SPACE = 1 TO 15:PRINT CLR$:NEXT:GOTO 2
120 'GET THEM AGAIN
2410 IF ANSWER$ <> "N" THEN PRINT:PRINT"TYPE ONLY Y OR N":GOTO 2390
2412 RETURN
2420 '****************************************
2430 '
2440 '* MANUAL POINT-TO-POINT PROGRAMMING *
2450 '
```

```
1408 PSTN = 23 - 4 'POSTION TO START INPUT LINE
1410 VTAB(PSTN):PRINT"ENTER CHOICE (1 -";NUMB;") ==>";:GET ANSWER$
1430 OPTION1 = INT(VAL(ANSWER$))
1440 IF OPTION1 = O OR OPTION1 > NUMB THEN PRINT:PRINT"TYPE ONLY 1 -";NUMB:GOTO
1410 'INPUT ERROR
1450 IF OPTION1 = NUMB THEN END 'ENDS PROGRAM
1460 'OPTION1 NOW HOLDS CORRECT MODE CHOICE
1470 RETURN
1480 '*************************************
1490 '
1500 '**** GET DATA TO DESCRIBE PART ****
1510 '
1520 ON OPTION1 GOSUB 1560,3020,3320 'GET DATA MANUALLY,FROM APPLE,FROM IBM
1530 RETURN
1532 '*********************************
1540 '
1550 '**** MANUAL TEXT GENERATION ****
1560 '
1570 GOSUB 1640 'GET CHOICE OF OPTION TO CREATE A NEW FILE OR MODIFY OLD
1590 ON OPTION2 GOSUB 1920,1600 'MODIFY OR CREATE
1600 RETURN
1610 '
1620 '**** CHOICE CREATE OR MODIFY ****
1630 '
1640 HOME
1650 PRINT SPC(3);"OPTIONS FOR MANUAL TEXT GENERATION"
1660 PRINT"***************************************":PRINT
1670 PRINT"1. CREATE NEW FILE":PRINT
1680 PRINT"2. MODIFY AN OLD FILE":PRINT
1700 VTAB(PSTN):PRINT"ENTER CHOICE (1-2) ==>";:GET ANSWER$
1710 OPTION2 = INT(VAL(ANSWER$))
1720 IF OPTION2 < 1 OR OPTION2 > 2 THEN PRINT:PRINT"ILLEGAL ENTRY":GOTO 1700
1730 RETURN
1740 '****************************************
1900 '
1910 '***** CREATE MANUALLY *****
1920 '
1930 GOSUB 2000 'GETS GENERAL PART DESCRIPTION
1940 GOSUB 2450 'DO POINT TO POINT PROGRAMMING
1950 RETURN
1960 '*****************************************
1970 '
1980 '** GET GENERAL PART DESCRIPTION ***
1990 '
2000 HOME
2010 PRINT SPC(7);"GENERAL PART DESCRIPTION"
2020 PRINT"**************************************"
2030 PSTN = 4 'POSTION TO START INPUT LINE
2032 CLR$="                                       "
2040 VTAB(PSTN):INPUT "ENTER PART NAME ==>",PRTNAME$
2050 VTAB(PSTN):PRINT CLR$:VTAB(PSTN):INPUT "ENTER PART NUMBER ==>",PRTNUMB$
2060 VTAB(PSTN):PRINT CLR$:VTAB(PSTN):PRINT"PART NAME IS ";PRTNAME$:PRINT
2070 PRINT"PART NUMBER IS ";PRTNUMB$
2080 VTAB(PSTN + 5):PRINT"DO YOU WISH TO CHANGE ANY":PRINT"OF ABOVE (Y/N) ? ";:G
ET ANSWER$:PRINT
2090 IF ANSWER$ = "Y" THEN HOME:GOTO 2010 ' GET AGAIN
```

```
2590 PRINT:PRINT "ERROR IN R AND F CHECK ROUTINE":END
2600 REM ***** CALCULATE SS FROM R AND F VALUES *****
2610 DENUM= (((256 - RATE) * 80) + (FEXP * 10) + 75) * .000001
2620 SSEXP= 1/DENOM
2630 SSERR=ABS(SS-SSEXP)
2640 RETURN
2650 REM ** CALCULATE SLOPE **
2660 IF SPEED < 12 THEN SLOPE = 255 : GOTO 2710
2670 SLOPE = 1
2680 YY = 2 * ( INT(( 255 - FACTOR ) / SLOPE ))
2690 IF SLOPE > 254 THEN GOTO 2710
2700 IF YY > STEPS THEN SLOPE = SLOPE + 1 : GOTO 2680
2710 RATE$=STR$(RATE):SLOPE$=STR$(SLOPE):FACTOR$=STR$(FACTOR):STEPS$=STR$(STEPS)
2720 CY$="R"+RATE$+",S"+SLOPE$+",F"+FACTOR$+",N"+STEPS$+","+DIRECTION$
2730 RETURN
2740 REM *****************************************
2750 REM * SUBROUTINE TO DO ARC INTERPOLATION
2760 REM *****************************************
2770 PRINT"ARC INTERPOLATION NOT AVAILABLE YET":GOSUB 3190:RETURN 'INTERPOLATION
 ERROR
2780 '
2790 REM *******************************
2800 REM * AXIS SPEED < 1.65 ERROR
2810 REM *******************************
2820 REM
2830 AXIS$=" "
2840 IF XSPEED < 1.65 AND XSPEED > 0 THEN AXIS$="X-AXIS"
2850 IF ZSPEED < 1.65 AND ZSPEED > 0 THEN AXIS$=AXIS$+",Z-AXIS"
2860 PRINT "INTERPOLATION CAUSES ";AXIS$;" TO"
2870 PRINT "TO BE LESS THEN MINIMUM OF 1.65 IN./MIN."
2880 GOTO 3190 'INTERPRETATION ERROR
2890 REM ********************************
2900 REM * AXIS SPEED > 112 ERROR
2910 REM ********************************
2920 REM
2930 IF XSPEED > 112 AND ZSPEED > 112 THEN AXIS$="X AND Z AXIS":GOTO 2960
2940 IF XSPEED > 112 THEN AXIS$="X AXIS"
2950 IF ZSPEED > 112 THEN AXIS$="Z AXIS"
2960 PRINT"FEED RATE WITH INTERPOLATION CAUSES ";AXIS$;
2970 PRINT"TO EXCEED MAX. OF 112 IN./MIN."
2980 GOTO 3190 'INTERPRETATION ERROR
2990 '
3000 ' ROUTINE TO HANDLE FILE NAME ERRORS
3010 '
3020 IF ERR=53 OR ERR = 64 THEN PRINT:PRINT"FILE NOT FOUND OR BAD FILE NAME":GOT
O 3050
3030 IF ERR = 62 THEN PRINT:PRINT"CYC FILE MISSING '$$$$' EOF MARKER":GOTO 3050
3040 PRINT:PRINT"ERROR LOADING FILE OTHER THAN BAD NAME"
3050 PRINT:PRINT"TYPE ANY KEY TO CONTINUE":GET HOLD$:GOTO 740 'EXITGOTO 502 'EXI
T PROAGRAM
3060 '
3070 'ILLEGAL CHARACTER ERROR
3080 '
3090 PRINT
3100 IF C$="Y" THEN PRINT"LATHE ONLY USES X AND Z AXIS":GOTO 3190
3110 IF C$>" " THEN PRINT"ILLEGAL CHARACTER '";C$;"'":GOTO 3190
```

```
3120 PRINT"ILLEGAL CHARACTER ASCII CODE";ASC(C$):GOTO 3190
3130 '
3140 'CONTAINS TWO OF SAME PARAMETER
3150 '
3160 PRINT"CONTAINS 2 OF SAME PARAMTER ";C$;" IN SAME LINE.":GOTO 3190
3170 '
3180 ' INTERPRETING ERROR FINAL ROUTINE
3190 '
3200 PRINT"ERROR IS IN LINE #";NLINE%
3210 PRINT SLINE$
3220 PRINT"THE";LNE%;" RD CONSECUTIVE LINE FROM THE BEGINNING"
3230 PRINT"TYPE C TO CONTINUE INTERPRETATION, ANY OTHER KEY EXITS";
3240 GET ANSWER$:IF ANSWER$ = "C" THEN INERROR%=1:RETURN 'SET INTERPRET ERROR FL
AG AND GO BACK TO INTERPRET NEXT LINE
3250 '
3260 ' READ IN INTERPRETED FILE
3270 '
3280 PRINT"LOAD FILE STARTED"
3290 ON ERROR GOTO 3010
3300 IF OPENED1%=0 THEN OPEN "I",#1,CY512$:OPENED1%=1
3310 TOTLINES%=MAXLINES%:EXMAXLINES%=1
3320 FOR LINES%=1 TO MAXLINES%
3330 INPUT #1,CYMOVE$(LINES%,1),CYMOVE$(LINES%,2)
3340 IF CYMOVE$(LINES%,1) = "$$$$" THEN TOTLINES%=LINES%-1:EXMAXLINES%=0:LINES%=
MAXLINES%
3350 NEXT:ON ERROR GOTO 0:RETURN
3360 '
3370 ' SEPARATE X,Y AND Z AXIS
3380 '
3390 COLON1=INSTR(CYMOVE$(LNE%,CY%),":")
3400 XP$=LEFT$(CYMOVE$(LNE%,CY%),COLON1-2)
3410 ZP$=MID$(CYMOVE$(LNE%,CY%),COLON1+2)
3420 '
3430 ' EXECUTE MOVE
3440 '
3450 Q$=USR1(XP$)
3460 Q$=USR3(ZP$)
3470 Q$=USR1("G"):Q$=USR3("G") 'SENDS GO TO BLUE BOX
3480 RETURN
3490 '
3500 ' TOOL CHANGE SUBROUTINE
3510 '
3520 'REINITIALIZE LATHE
3530 '
3540 PRINT:PRINT"REINITIALIZING LATHE"
3550 STAT1=&HE0F0:STAT2=&HE0F2
3560 CY1$="I,R 250,S 1,F 1,N 10000,+,G":CY2$="I,R 220,S 1,F 1,N 20000,-,G"
3570 Q$=USR1(CY1$)
3580 X$=RIGHT$((HEX$(PEEK(STAT1))),1)
3590 IF ASC(X$) > 55 THEN POKE STAT1,&H44:POKE STAT1,&H40:GOTO 3610
3600 GOTO 3580
3610 Q$=USR3(CY2$)
3620 Z$=RIGHT$((HEX$(PEEK(STAT2))),1)
3630 IF ASC(Z$) > 55 THEN POKE STAT2,&H44:POKE STAT2,&H40:GOTO 3650
3640 GOTO 3620
3650 CY1$="R 100,S 1,F 1,N 15,+,G":CY2$="R 100,S 1,F 1,N 15,-,G"
```

```
3660 Q$=USR1(CY1$):Q$=USR3(CY2$)
3670 ABX=0:ABZ=0 'RESET ABSOLUTE REGISTERS
3680 '
3690 ' DISPLAY TOOL NUMBER
3700 '
3710 T$=MID$(CYMOVE$(LNE%,MC%),INSTR(CYMOVE$(LNE%,MC%),"T")+1)
3720 PRINT:PRINT "LOAD TOOL #";T$
3730 PRINT:PRINT "TYPE R WHEN READY TO CONTINUE."
3740 GET ANSWER$:IF ANSWER$ <> "R" GOTO 3730
3750 RETURN
3760 '
3770 ' DO AGAIN ?
3780 '
3790 PRINT:PRINT:PRINT"DO YOU WISH TO MAKE SAME PART AGAIN ? (Y FOR YES)";:GET A
NSWER$
3800 IF ANSWER$ <> "Y" THEN CSTOP=1 ELSE CSTOP=0
3810 RETURN
```

Students who have been engaged with the development of the Manufacturing Information System at Brigham Young University.

Year	Name of Student	Major	Description of Work
Prior to Grant			
1978	Duane Schow	Staff	Installation of ball screws and stepper motors on lathe and mill
1978	Charles Snedd	CAM, M.S.	Tectronix 4051/MACSYM/
1980	Val Hubbard	Mfg. Tech	Parametric design, TEK 4051
1980	Doug Bushman	Ind. Design	Parametric design, Apple II
1981	Marvin Quist	CAM, M.S.	AS/RS design and evaluation
	Forest Blair	Mech. Eng.	Design of equipment
After Grant			
1982	Forest Blair	Mech. Eng.	Design of equipment
1982	Justin Redd	El. Eng.	Stepper motor drives
1983	David Jesperson	Mfg. Tech.	Programming, Demo System
1983	Bruce Ross	Design Tech.	Mechanical Draftsman
1983	Tim Ward	Mfg. Tech.	Equipment Fabrication
1983	John Oliver	Mfg. Tech.	Equipment Fabrication
1983	Greg Peto	El. Eng.	Programming
1983	Stanley Livingston	El. Eng.	Mechanical Drafting
1984	Darin Mathews	Mfg. Tech.	Equipment Fabrication